CLIMATE CHANGE AND HUMAN DEVELOPMENT: EXTENDING THE VISION OF DR. MAHBUB UL HAQ

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Does Critical Criticism believe that it has reached even the beginning of a knowledge of historical reality so long as it excludes from the historical movement the theoretical and practical relation of man to nature, i.e. natural science and industry?

—KARL MARX AND FREDERICK ENGELS

For it is because we are kept in the dark about the nature of human society—as opposed to nature in general—that we are now faced (so the scientists concerned assure me), by the complete destructibility of this planet that has barely been made fit to live in.

—BERTOLT BRECHT

Abstract

Climate change is not a "natural" disaster, but a creation of the system that is aimed in pursuit of private profit at increasing scale. The implications and effects of climate change can be considered as one of the key factors in determining not only the welfare of human being but also the existence of other life forms and our planet. The principal submission of this paper is, extending and advancing the insight of Dr Mahbubul Haq and his team's work on Human Development Index, to another important step by including the negative impact of climate change. This paper uses carbondioxide emission of a given country as a proxy to capture the adverse effects on climate change and incorporates that into the HDI in a way that higher carbondioxide emissions lowers the HDI and renamed it as Clean Air Adjusted HDI. The new index changes the current HDI ranking of countries by pushing down the countries with heavy air pollution. Findings of this study can be useful specifically to countries with higher level of emissions to reconsider their relative ranking in terms of Clean Air Adjusted HDI, to bring down the emission levels. Further, International Agencies work on Human

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Development can give country specific recommendations to improve HDI ranking and also to mitigate adverse consequences on the environment.

Keywords: HDI, anthropocene, capitalocene, climate change, UNDP, vulnerability

The philosopher Jacques Derrida once wrote an essay called "Of an Apocalyptic Tone Recently Adopted in Philosophy". That tone has recently entered into everyday political discourse with the warnings of climatologists all over the world of the incoming avalanche of ecological disaster notwithstanding Donald Trump's victory in the recently held US Presidential Election. With the ambiguous term "sustainable" introduced into development lexicon in recent years, attempts have been made to resolve the issue without disturbing the status quo in the prevailing economic and social system. What is the nexus between climate change and economic and social development? How can this nexus be reflected in economic and social development indices? These and other associated questions remind us of seemingly unrelated two discourses in the recent years. The first is the debate on enlightenment. How rational is the enlightenment project? This is the question raised by Horkheimer and Adorno in their work, *Dialectics of Enlightenment*. The second issue refers to how development should be measured giving its human dimension a proper place. The team of development economists led by Dr. Mahbub ul Haq had focused on this aspect in the latter part of the last century.

Measuring the wealth of nations using extremely crude methods of calculation goes back at least to middle ages since the tax on production was the principal source of income of the ruling classes of the medieval society, both secular and ecclesiastical. How the tax system can be related to the level of production had invariably become one of the key problematic issues of the feudal ruling classes as well as the colonial masters. However, the method of calculation is not only crude but also spatially local. As Jairus Banaji (2010) (has revealed, the calculation in the middle ages depended on the surface in production and the size of the disposable labor-power.[1] However, the process of modernity and the rise of the absolute state called for a more systematic collection of production data at national level. As David Landes has argued, Mercantilism had made it imperative the collection of economic and social statistics.[2] An economist of Mercantilist tradition, William Petty has been regarded as the person who pioneered the modern system of national accounts.

The objectives of the collection of national income account varies significantly from time to time. Mercantilist ideas were advanced on the same cognitive basis of natural

[1] "As the level of technique progressed only slowly, over several centuries, as our figures indicate, the estate's output was a function of the surface in production, and the surface which the lord could bring into production in any given period was a function of the disposable mass of labour-power.", Jairus Banaji, *Theory as History: Essays on Mode of Production and Exploitation*. (Boston: Brill, 2010) p.73

[2]David S Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*. (UK: Cambridge University Press, n.d.) p.32.

science so that the performance was the main criterion in the process of calculation.[3] Whether an economy performs well or not at a given time thus depends on the size of its total output and the level of per capita income. So the time series data on national and per capita income and their growth are considered as the main indicators of economic performance. The implicit assumption is that the increase in per capita income would eventually increase the welfare of the people in the country. This assumption had been questioned with reference to income distribution between different classes of society. Hence, the supplementary data on income distribution is collected and the Gini coefficient is calculated to demonstrate how income levels are deviated from the average.

Dr. Mahbubul Haq's pioneering work were aimed at addressing a more qualitative dimension of economic and social progress bringing in the level of performance in the sphere of education and health. Following his footsteps and extending his vision, this paper submits a case that in the light of experience in the last three decades or so, the development index has to be added and enriched making them indicators of a more rational and humane economic growth. In contemporary world, the implications and effects of climate change can be considered as one of the key factors in determining not only the welfare of human being but also the existence of other life forms and our planet. Humanity's relationship with the rest of nature has always been a tricky issue. However, with the advent of modernity roughly about 300 years ago, the subject has become trickier.

The principal submission of this paper is that extending and advancing the insight of Dr Mahbubul Haq and his team, we should take another important step by including the negative impact of climate change into Human Development Index so that such an expanded composite index would contribute immensely in policy-making process. Thus the indices would be able to capture both the positive and negative dialectics of enlightenment and the modernization process.

The paper consists of five sections: First section discusses the multi-faceted nature of human progress and the inherent drawbacks of mono-focused measurement. Section 2 briefly presents how HDI has been calculated since 2010 while Section 3 focuses on the new challenge of development, the climate change. How we understand the climate change is the subject of Section 4. On the basis of that argument Section 5 briefly outlines how HDI be improved and expanded still as a composite index by incorporating the negative aspect of development. A brief conclusion will follow. The climate change adjusted HDI for all countries is given in the Appendix at the end.

Multi-Faceted Progress and Mono-Focused Measurement

The social progress and development has always been multi-dimensional. Nobel laureate Prof Amatya Sen has argued in the opening sentence of his book, *Development as Freedom*:

[3]*Ibid.*

> Development can be seen, ..as a process of expanding the real freedoms that people enjoy. Focusing on human freedoms contrasts with narrower views of development, such as identifying development with the growth of gross national product, or with the rise in real incomes, or with industrialization, or with technological advance, or with social modernization.[4]

Of course, it does not mean that the increase of GNP is of no importance. When Marx hypothesized the historical trajectory of human progress as from freedom to necessity and then from necessity to freedom, he emphasized the importance of increase in production as a material basis of freedom. It is interesting to note that there is a difference between the freedom at the point of departure and the freedom at the end point. Nonetheless, "freedoms depend also on other determinants, such as social and economic arrangements (for example, facilities of education and health care) as well as political and civil rights (for example, the liberty to participate in public discussion and scrutiny)".[5] In the early development discourse, it had been surmised that the growth of GNP would sooner or later contribute to the improvements in social and economic arrangements and advance in political and civil rights. However, during the post-World War 2 long boom in the world economy, many countries experienced substantial growth in GNP and per capita income, but no significant gain in educational or health standards. On the contrary, in Sri Lanka, although its growth record was relatively poor, a significant progress had been made in the 1950s and 1960s in educational and health standards. This was one of the conundrums that the development economist had to encounter in defining and measuring economic development and social progress. In addition, the second problem had been how multi-dimensional social and economic progress could be captured by a single development index. In order to resolve these twin issues, Dr Mahbub ul Haq formed a group of well-known development economists including Paul Streeten, Frances Stewart, Gustav Ranis, Keith Griffin, Sudhir Anand, and Meghnad Desai. The team also worked with Prof Amartya Sen who developed capabilities approach in his studies on poverty.

Initially, there was a disagreement between Dr. Haq and Prof. Sen. Being an economist focusing more on theoretical and philosophical aspects, Prof. Sen was in a view that it was not easy to capture a very complex and multi-dimensional process in a single index. On the other hand, Dr Haq was not only an academician, but a person who was directly involved in policy making as a finance minister in Pakistan. Hence, he knew that the politicians and policy makers may not go with the philosophical arguments but would seek for tangible results in implementation of policies. Thus he emphasized the need of a single index that would attract immediate attention of the politicians. They finally reached a compromise that a composite index should be developed taking limited but highly important factors into consideration.[6] In developing the Human Development

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[4]Amartya Sen, *Development as Freedom*, (New Delhi: Oxford University Press, n.d.) p.3
[5]*Ibid.*
[6]https://en.wikipedia.org/wiki/Human_Development_Index.

Index, it had been suggested that three principal dimensions must be combined giving an equal weightage. They are:

1. A long and healthy life: Life expectancy at birth;
2. Education index: Mean years of schooling and Expected years of schooling; and
3. A decent standard of living: GNI per capita (PPP US$).

Dr. Haq's contribution has had a deep rooted impact on development thinking and practice. His contribution has been appreciated and the notion of HDI has played an important role in designing UN millennium goals. Amartya Sen and Tam Dalyell termed Haq's work to have "brought about a major change in the understanding and statistical accounting of the process of development".[7] Moreover, UN Millennium Development Goals were designed following the argument embedded in the HDI discourse.

Human Development Index

The calculating method of HDI has changed considerably in the last two decades. In its 2010 Human Development Report, the UNDP began using a new method of calculating the HDI. The geometric mean of the following three indices was used in calculating the *HDI* (The geometric mean is defined as the n^{th} root of the Product of *n* numbers).

1. ***Life Expectancy Index (LEI)*** LE -20/ 85-20

   LEI is 1 when Life expectancy at birth is 85 and 0 when Life expectancy at birth is 20.

2. ***Education Index (EI)*** MYSI + EYSI/ 2

   2.1 Mean Years of Schooling Index (MYSI) MYS/ 15

   Fifteen is the projected maximum of this indicator for 2025.

   2.2 Expected Years of Schooling Index (EYSI) EYS/ 18

   Eighteen is equivalent to achieving a master's degree in most countries.

3. ***Income Index (II)*** *ln* (GNIpc) –*ln* 100 / *ln* (75000) – *ln* (100)

   II is 1 when GNI per capita is $75,000 and 0 when GNI per capita is $100.

Finally, the HDI is the geometric mean of the previous three normalized indices:

[7] *The Economist*. 2016-02-23 as quoted in www.wikipedia.com

New Challenges to Human Development

The concept of human development should not be viewed as static but dynamic. When the development process encounters new challenges, the concept has to be reviewed, reread and developed in order to capture the new reality. The new reality embedded with so many challenges was comprehensively analyzed by Amartya Sen in his recent writings. He opines: "Development requires the removal of major sources of unfreedom: poverty as well as tyranny, poor economic opportunities as well as systematic social deprivation, neglect of public facilities as well as intolerance or over activity of repressive states."[8] He and many other writers have also raised the importance of gender equality as an indicator of human progress.

All these issues that have been raised in making the development multi-dimensional stems from the enlightenment project of the 18th and 19th centuries, i.e. to the process of modernity. One of the key issues that has been gradually coming to the fore is the emerging ecological disaster that is also a direct outcome of the modernist project. Its impact can be seen in every nook and corner of the globe today.

According to a monthly analysis of global temperatures by scientists at NASA's Goddard Institute for Space Studies (GISS) in New York, August 2016 was the warmest August in 136 years of modern record-keeping; air pollution in mega cities like Beijing and Delhi has reached an unbearable level. A report by the American Association for the Advancement of Science, the world's largest general scientific society puts the magnitude of the issue in the following words:

> Most projections of climate change presume that future changes—greenhouse gas emissions, temperature increases and effects such as sea level rise—will happen incrementally. A given amount of emission will lead to a given amount of temperature increase that will lead to a given amount of smooth incremental sea level rise. However, the geological record for the climate reflects instances where a relatively small change in one element of climate led to abrupt changes in the system as a whole. In other words, pushing global temperatures past certain thresholds could trigger abrupt, unpredictable and potentially irreversible changes that have massively disruptive and large-scale impacts. At that point, even if we do not add any additional CO2 to the atmosphere, potentially unstoppable processes are set in motion. We can think of this as sudden climate brake and steering failure where the problem and its consequences are no longer something we can control.[9]

It seems that the ecological impact of climate change has already passed the threshold point and the best symbolic example for this is what has already happened to the Australian Great Barrier Reef which is 25 million years old. Rowan Jacobsen has written its obituary.

> For most of its life, the reef was the world's largest living structure, and the only one visible from space. It was 1,400 miles long, with 2,900 individual

[8]Amartya Sen, Op.cit. p.3
[9]Report by the American Association for the Advancement of Science, 2014

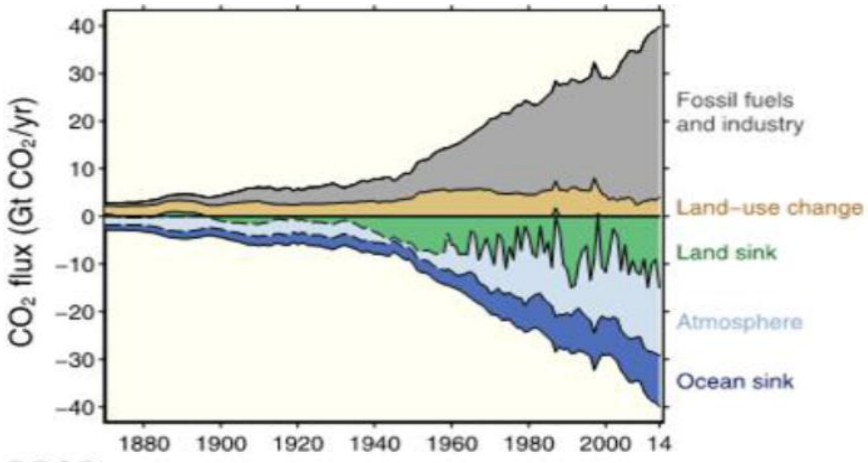
> reefs and 1,050 islands. In total area, it was larger than the United Kingdom, and it contained more biodiversity than all of Europe combined. It harbored 1,625 species of fish, 3,000 species of mollusk, 450 species of coral, 220 species of birds, and 30 species of whales and dolphins. Among its many other achievements, the reef was home to one of the world's largest populations of dugong and the largest breeding ground of green turtles.[10]

In spite of many international conferences and decisions, the problem remains essentially unresolved. This fact is even recognized by the World Bank in its recent report. The Report says:

> As global warming approaches and exceeds 2-degrees Celsius, there is a risk of triggering nonlinear tipping elements. Examples include the disintegration of the West Antarctic ice sheet leading to more rapid sea-level rise, or large-scale Amazon dieback drastically affecting ecosystems, rivers, agriculture, energy production, and livelihoods. This would further add to 21st-century global warming and impact entire continents.[11]

Annual anthropogenic CO2 emission and their partitioning among atmosphere, land and ocean from 1750 to 2014 is shown in Figure 1. [12]

Figure 1: CO2 Emission between 1750- 2014



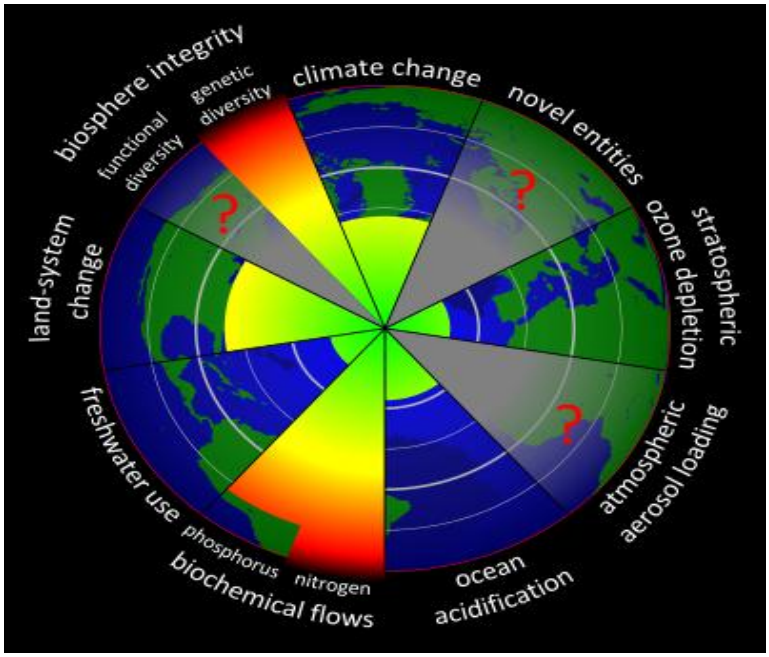
Source: Global Carbon Project. CDIAC/NOAA-ESRL/GCP/Joos et al. 2013/Khatiwala et al. 2013

A well-known climatologist and an activist on climate change, James Hanson has once mentioned that the world is moving towards a climate cliff. In such a situation, according to Kevin Anderson and Alice Bose of Manchester University, UK, the

[10]http://www.spokesman.com/blogs/outdoors/2016/oct/13/great-barrier-reef-pronounced-dead-scientists/
[11]World Bank, Development Report 2012.
[12]As cited in: http://www.ipcc.ch/pdf/unfccc/specialevent_summaryreport_online.pdf

intergovernmental agreement to maintain world warming within centigrade 2 limit may even become obsolete. They also argue that this would lead to submerging some areas under sea water, floods and the reduction in agricultural production. The concept of Planetary boundaries was developed as a central concept in an Earth system framework by a group led by Johan Rockström from the Stockholm Resilience Centre and Will Steffen from the Australian National University. They have identified nine boundaries marking "safe operating space for humanity". They assert that once human activity has passed certain thresholds or tipping points, defined as "planetary boundaries", there is a risk of "irreversible and abrupt environmental change".[13] The nine boundaries are: (1) climate change; (2) novel entities; (3) Stratospheric ozone deprivation; (4) atmospheric aerosol loading; (5) ocean acidification; (6) biogeochemical flows; (7) Freshwater use; (8) Land-system change; and (9) biosphere integrity.

Figure 2: Planetary Boundaries



The green areas represent human activities that are within safe margins, the yellow areas represent human activities that may or may not have exceeded safe margins, the red areas represent human activities that have exceeded safe margins, and the gray areas

[13]https://en.wikipedia.org/wiki/Planetary_boundaries

with red question marks represent human activities for which safe margins have not yet been determined.[14]

Scientists during the last few years have sought to designate 'a safe operating space for humanity', constituted by nine planetary boundaries, nearly all of which now have either been crossed or are in the process of being crossed, as seen in: climate change; ocean acidification; destruction of the ozone layer; biosphere integrity; disruption of bio-chemical flows; land-system change, fresh water use, aerosol loading; and the introduction of novel entities (new chemical and biological substances).[15]

Anthropocene or Capitalocene

How do we explain this global phenomenon? As John Bellamy Foster and Paul Burkett argue "Standard, possessive-individualist social science, and much of contemporary environmental theory – in so far as it is an offshoot of the mainstream liberal tradition – have found themselves incapable of going to the root of the problem in this respect".[16] There are many attempts to understand the phenomenon of crossing planetary boundaries. One such attempt is to define the present epoch as Anthropoene. John Bellamy Foster has given the following definition for Anthropocene.

> The Anthropocene, viewed as a new geological epoch displacing the Holocene epoch of the last 10,000 to 12,000 years, represents what has been called an "anthropogenic rift" in the history of the planet. Formally introduced into the contemporary scientific and environmental discussion by climatologist Paul Crutzen in 2000, it stands for the notion that human beings have become the primary emergent geological force affecting the future of the Earth system. Although often traced to the Industrial Revolution in the late eighteenth century, the Anthropocene is probably best seen as arising in the late 1940s and early 1950s. Recent scientific evidence suggests that the period from around 1950 on exhibits a major spike, marking a Great Acceleration in human impacts on the environment, with the most dramatic stratigraphic trace of the anthropogenic rift to be found in fallout radionuclides from nuclear weapons testing.[17]

It is true that since the industrial revolution and the process of modernity began, human impacts on nature and environment grew dramatically in leaps and bounds as the initial balance between humans and nature was redefined and transformed on the basis of the instrumental rationalist notion of the enlightenment project. While accepting that the initial balance between humans and nature had been disturbed owing to the fact that

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[14]Steffen, W.; Richardson, K.; Rockstrom, J.; Cornell, S. E.; Fetzer, I.; Bennett, E. M.; Biggs, R.; Carpenter, S. R.; De Vries, W.; De Wit, C. A.; Folke, C.; Gerten, D.; Heinke, J.; Mace, G. M.; Persson, L. M.; Ramanathan, V.; Reyers, B.; Sorlin, S. (2015). "Planetary boundaries: Guiding human development on a changing planet". *Science*. 347 (6223): 1259855; and https://en.wikipedia.org/wiki/Planetary_boundaries.

[15] John Bellamy Foster and Paul Burkett. *Marx and the Earth: An Anti Critique*. (New York: Monthly Review Press, 2017) p.222

[16] *Ibid*. p.223

[17]John Bellamy Foster. "Anthropocene Crisis". *Monthly Review*. No. 68, Issue 4

humans began to share the notion that it was the task of the humans to control and dominate everything in the interests of human well-being, some social scientists have questioned if humans in general could be blamed for this process. John W Moore has focused on this drawback of the Anthropocene idea.

> The motive force behind this epochal shift? In two words: coal and steam. The driving force behind coal and steam? Not class. Not capital. Not imperialism. Not even culture. But… you guessed it, the *Anthropos*: humanity as an un-differentiated whole.[18]

He further added:

> The Anthropocene makes for an easy story. Easy, because it does not challenge the naturalized inequalities, alienation, and violence inscribed in modernity's strategic relations of power and production. It is an easy story to tell because it does not ask us to think about these relations *at all*. The mosaic of human activity in the web of life is reduced to an abstract humanity as homogenous acting unit. Inequality, commodification, imperialism, patriarchy, and much more.[19]

His principal criticism against the idea of Anthropocene is that the idea is mono-centric and has failed to capture the mosaic of developments that had been associated with the emergence and development of capitalist mode of production. Under capitalist mode of production the human-nature relationship has undergone a metamorphosis to promote the process of capital accumulation. The driving behind coal and steam and later fossil fuel and nuclear power are not humans in abstract but capital. Hence he coined with the term 'Capitalocene' in place of Anthropocene.

A somewhat essentially similar argument has been proposed by John Bellamy Foster, Paul Burkett and the Monthly Review group. Their point of departure is the statement by Marx and Engels. Karl Marx and Frederick Engels remarked as early as 1845, "Nature, the nature that preceded human history, no longer exists anywhere (except perhaps on a few Australian coral islands of recent origin)".[20] This school argues that Marx and Engels have developed an outline (though in undeveloped or unfinished form) that can be used in developing a new theoretical framework that could capture the complexity of current ecological problem. It has been argued that the analysis should be based on the dialectical approach implicit in Marx's triadic scheme of "the universal metabolism of nature," the "social metabolism," and the metabolic rift. Hence John Bellamy Foster and Brett Clark opine:

> In the Anthropocene epoch, it is therefore all the more necessary to explore the complex, dialectical natural-social interconnections between the Earth system as a whole and capitalism as a system of alienated social metabolic reproduction *within* that Earth system. Today the drive to capital accumulation is disrupting the planetary metabolism at cumulatively higher levels,

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[18]John W Moore, "The Capitalocene: On the Nature and origins of Our Ecological Crisis". http://www.jasonwmoore.com/uploads/The_Capitalocene__Part_I__June_2014.pdf
[19]*Ibid*.
[20]Karl Marx and Fredrick Engels. *Collected Works*. Vol. 5. (Moscow: Progress Publishers) p. 40

> threatening irreversible, catastrophic impacts for countless species, including our own. It is in the theorization of this ecological and social dialectic, and in the development of a meaningful praxis to address it, that Marx's analysis has proven indispensable.[21]

When Marx's above cited triadic scheme is deployed in the analysis of the "climate cliff", climate change and ecological issues may be seen as a natural corollary of capitalist system of production in which in the "pursuit of profit, "capitalists are driven to accumulate ever more capital, and this becomes both their subjective goal and the motor force of the entire economic system".[22] Hence climate change is not a "natural" disaster, but a creation of the system that is aimed in pursuit of private profit at increasing scale.

Revisiting the HDI

The above discussion leads us to focus on the negative aspects of the enlightenment project that had developed as a capitalist project. The dialectics of enlightenment while accepting the positive dimensions of modern development that are at the moment included in the calculation of HDI, forces us to embed negative dimensions as well as modern development. Hence we submit that climate change has to be introduced into the HDI calculation as a negative element. In this essay we do not make an attempt to calculate comprehensive composite index that embodies both the positive and negative aspects of modern development, but it makes an attempt to flag the idea by adding the negative factor using carbon emission as a proxy to HDI calculation.

Two suggestions may be made on how the incidence of climate change be incorporated into HDI index. First is linking the impact of climate change to health indices of the current HDI calculation. Although it may be easy to do so as far as the easiness of measurement is concerned, it is reductionist in the sense that climate changes affect only human health standards. The impact of climate change affects all other life forms and the existence of the planet. Hence it is not advisable to do so as it is still a trap us within modernist project.

The better way to incorporate climate change factor is to include it as a negative component to existing HDI. Hence, suppose Country A has high HDI value but it release higher level of carbon to the atmosphere. As a result, under this system, its HDI value will go down. On the other hand, suppose that Country B has lower HDI value but it emits no carbon to the atmosphere or lower than the accepted level of carbon. In final HDI calculation, the value of the HDI of Country B will go up (Table 1).

[21]John Bellamy Foster, Brett Clark. "Marx's Ecology and the Left". *Monthly Review*. Vol. 68. Issue 2. (n.pub. 2016)

[22]Paul M Sweezy. Capitalism and the Environment, "*Monthly Review*56, No. 5 (2004): 86–93.

Table 1: HDI Ranking of 10 Selected Countries

Country and Current Group in HDI Ranking	HDI Rank-2014 (UNDP 2015 Report. Ranking out of 188 countries)	Clean air adjusted HDI Rank 2014 (out of 180 countries used in the study)
Very High HDI		
Australia	2	1
Germany	6	17
USA	8	113
High HDI		
Brazil	75	74
China	90	180
Sri Lanka	73	68
Medium HDI		
Indonesia	110	107
India	130	134
Low HDI		
Pakistan	147	141
Nigeria	152	145

See Appendix 1 for Calculation Method of Clean Air Adjusted HDI.

Conclusion

The principal submission of this paper is that extending and advancing the insight of Dr Mahbub ul Haq and his team, we should take another important step by including the negative impact of climate change into Human Development Index so that such an expanded composite index would contribute immensely in policy-making process. Particularly those countries that contribute a high level of carbon dioxide emissions have to make an extra effort to lower it. This paper shows, to what extent it affects the relative Ranking of HDI (Clean Air Adjusted HDI) by pulling down the HDI ranking of

countries with high level of emissions. Such countries can reconsider their emission related domestic policies in terms of improving HDI. At the global level adverse effects of climate change will have amplified effect on vulnerable countries (As identified in the UNDP report on "Climate Change 2001: Impact Adaptation and Vulnerability). International agencies such as UNDP can emphasis this fact and can incorporate into country specific policy recommendations.

Appendix: Table 1: Current and Clean Air Adjusted HDI for 2014 (for 180 Countries)

No	Country	Life Expectancy Index[a]	Education Index[a]	GNI Index[a]	CO_2[b] (Million Metric Tons)	Clean Air Index[c]	HDI[a]	HDI Rank[d]	Clean Air Adjusted HDI[c]	Clean Air Adjusted HDI Rank[e]
1	Norway	0.969011	0.933947	0.978366	40.005060	0.995431	0.944	1	0.968927	2
2	Australia	0.981595	1.034130	0.913350	370.352477	0.957649	0.935	2	0.970706	1
3	Switzerland	0.991034	0.882556	0.957029	39.623937	0.995475	0.930	3	0.955425	5
4	Denmark	0.946988	0.976572	0.919530	35.544410	0.995941	0.923	4	0.959317	3
5	Netherlands	0.969011	0.927703	0.924290	231.993993	0.973473	0.922	5	0.948347	7
6	Ireland	0.957999	0.957851	0.903405	33.669397	0.996156	0.916	6	0.953275	6
7	Germany	0.957999	0.911531	0.919162	742.413727	0.915097	0.916	6	0.925761	17
8	United States	0.929684	0.908848	0.947402	5411.885620	0.381048	0.915	8	0.743165	113
9	New Zealand	0.972157	0.985850	0.874558	37.634610	0.995702	0.913	9	0.955798	4
10	Canada	0.975303	0.890393	0.912972	604.378417	0.930884	0.913	9	0.926869	13
11	Singapore	0.991034	0.808611	1.003244	223.103087	0.974490	0.912	11	0.940812	10
12	Hong Kong, China	1.006764	0.829919	0.950264	83.852597	0.990416	0.910	12	0.941687	9
13	Sweden	0.978449	0.863148	0.924955	46.361797	0.994704	0.907	14	0.938879	11
14	United Kingdom	0.954853	0.902059	0.902252	441.943503	0.949461	0.907	14	0.926817	14
15	Iceland	0.984741	0.926730	0.885658	2.693120	0.999699	0.899	16	0.948097	8
16	Korea (Republic of)	0.973730	0.892758	0.880008	631.166820	0.927820	0.898	17	0.917869	22
17	Israel	0.981595	0.880218	0.864953	65.806511	0.992480	0.894	18	0.928024	12
18	Luxembourg	0.970584	0.788055	0.963013	10.447417	0.998812	0.892	19	0.926139	15
19	Japan	0.998899	0.830878	0.892970	1157.797420	0.867589	0.891	20	0.895473	30

20	Belgium	0.956426	0.857532	0.909462	128.386950	0.985323	0.890	21	0.925905	16
21	France	0.978449	0.842643	0.897521	327.617620	0.962537	0.888	22	0.918673	21
22	Austria	0.965864	0.825841	0.918993	60.325693	0.993107	0.885	23	0.923698	19
23	Finland	0.956426	0.854703	0.900034	42.074290	0.995195	0.883	24	0.925035	18
24	Slovenia	0.950134	0.890540	0.850368	11.912337	0.998644	0.880	25	0.920691	20
25	Spain	0.984741	0.844335	0.871550	264.015380	0.969811	0.876	26	0.915596	23
26	Italy	0.992607	0.815340	0.876124	340.471273	0.961067	0.873	27	0.908571	27
27	Czech Republic	0.921818	0.888556	0.843761	95.512630	0.989083	0.870	28	0.909276	26
28	Greece	0.957999	0.872600	0.831145	70.764887	0.991913	0.865	29	0.911135	25

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29	Estonia	0.893503	0.896151	0.835336	5.179757	0.999414	0.861	30	0.904214	29
30	Brunei Darussalam	0.924965	0.727875	0.995025	9.087277	0.998967	0.856	31	0.904465	28
31	Qatar	0.915526	0.711519	1.074879	113.841957	0.986987	0.850	32	0.911763	24
32	Cyprus	0.946988	0.788303	0.854543	7.009300	0.999205	0.850	32	0.893525	31
33	Slovakia	0.885638	0.841743	0.839071	30.134580	0.996560	0.844	35	0.888556	32
34	Poland	0.902942	0.843973	0.822610	280.589786	0.967916	0.843	36	0.882582	38
35	Malta	0.953280	0.767156	0.850791	6.700000	0.999240	0.839	37	0.887972	33
36	Lithuania	0.838446	0.890268	0.830999	13.382747	0.998476	0.839	37	0.887122	34
37	Saudi Arabia	0.854176	0.784007	0.947044	575.837688	0.934148	0.837	39	0.877331	42
38	Argentina	0.885638	0.871411	0.815078	188.856513	0.978407	0.836	40	0.885726	36
39	United Arab Emirates	0.896649	0.707991	0.968463	229.374813	0.973773	0.835	41	0.879626	39
40	Chile	0.970584	0.780065	0.809784	75.607806	0.991359	0.832	42	0.882960	37
41	Portugal	0.957999	0.772862	0.838553	48.418897	0.994469	0.830	43	0.886436	35
42	Hungary	0.868334	0.836163	0.820899	45.971926	0.994749	0.828	44	0.877496	41
43	Bahrain	0.890357	0.741639	0.899658	39.560417	0.995482	0.824	45	0.876934	43
44	Latvia	0.852603	0.826949	0.816652	6.950367	0.999212	0.819	46	0.870924	44
45	Croatia	0.901369	0.799893	0.795814	17.520507	0.998003	0.818	47	0.869900	45
46	Kuwait	0.855750	0.691745	1.017048	98.673707	0.988721	0.816	48	0.878369	40
47	Montenegro	0.884065	0.815923	0.752369	2.207120	0.999754	0.802	49	0.858251	46
48	Belarus	0.806984	0.854697	0.772886	64.402570	0.992641	0.798	50	0.852896	49
49	Russian Federation	0.788108	0.821646	0.817136	1737.275590	0.801314	0.798	50	0.806941	78

50	Uruguay	0.899796	0.751487	0.794830	8.612809	0.999022	0.793	52	0.856010	47
51	Oman	0.893503	0.676745	0.884259	70.031223	0.991997	0.793	52	0.853400	48
52	Romania	0.860469	0.773058	0.785329	68.747593	0.992144	0.793	52	0.848484	50
53	Bahamas	0.871480	0.722979	0.810112	3.700000	0.999584	0.790	55	0.845156	52
54	Kazakhstan	0.777096	0.818005	0.806754	209.224040	0.976078	0.788	56	0.841132	55
55	Barbados	0.874626	0.804472	0.729194	1.818205	0.999799	0.785	57	0.846296	51
56	Antigua and Barbuda	0.882492	0.721688	0.800871	0.700000	0.999927	0.783	58	0.845080	53

No	Country	Life Expectancy Index[a]	Education Index[a]	GNI Index[a]	CO_2[b] (Million Metric Tons)	Clean Air Index[c]	HDI[a]	HDI Rank[d]	Clean Air Adjusted HDI[c]	Clean Air Adjusted HDI Rank[e]
57	Bulgaria	0.852603	0.771980	0.762771	48.065637	0.994509	0.782	59	0.840600	56
58	Panama	0.906088	0.702300	0.786029	22.788970	0.997400	0.780	60	0.840427	57
59	Malaysia	0.860469	0.701168	0.819883	225.703407	0.974193	0.779	62	0.833179	60
60	Mauritius	0.855750	0.756509	0.779909	5.422100	0.999387	0.777	63	0.842820	54
61	Seychelles	0.835300	0.707235	0.823413	1.000000	0.999892	0.772	64	0.835111	59
62	Trinidad and Tobago	0.792827	0.713821	0.840495	56.575136	0.993536	0.772	64	0.829128	63
63	Serbia	0.863615	0.770134	0.725556	44.794157	0.994884	0.771	66	0.832401	61
64	Lebanon	0.932830	0.678381	0.771367	22.000000	0.997491	0.769	67	0.835337	58
65	Cuba	0.934403	0.780683	0.648120	30.749676	0.996490	0.769	67	0.828484	64
66	Costa Rica	0.934403	0.694500	0.739997	7.102177	0.999194	0.766	69	0.832284	62
67	Iran (Islamic Republic of)	0.871480	0.730085	0.761250	645.973637	0.926127	0.766	69	0.818384	70
68	Venezuela (Bolivarian Republic of)	0.852603	0.721037	0.768127	180.154303	0.979402	0.762	71	0.824660	65
69	Turkey	0.869907	0.694818	0.790004	319.661286	0.963447	0.761	72	0.823570	66
70	Sri Lanka	0.863615	0.757112	0.692255	17.415470	0.998015	0.757	73	0.819824	68
71	Mexico	0.893503	0.670573	0.767162	433.901603	0.950381	0.756	74	0.812984	75
72	Brazil	0.857323	0.719225	0.758637	543.909943	0.937800	0.755	75	0.813838	74
73	Georgia	0.863615	0.796284	0.645258	7.542080	0.999144	0.754	76	0.815995	71
74	Saint Kitts and Nevis	0.845839	0.662155	0.806301	0.300000	0.999972	0.752	77	0.819753	69
75	Azerbaijan	0.799119	0.708006	0.770621	37.095689	0.995764	0.751	78	0.811730	76

76	Grenada	0.840019	0.764348	0.709195	0.300000	0.999972	0.750	79	0.821454	67
77	Jordan	0.849457	0.725522	0.714968	22.795850	0.997400	0.748	80	0.814211	73
78	The former Yugoslav Republic of Macedonia	0.871480	0.702332	0.720384	7.636083	0.999133	0.747	81	0.814698	72
79	Ukraine	0.802265	0.819712	0.665256	225.943850	0.974165	0.747	81	0.807979	77
80	Algeria	0.862042	0.676928	0.735899	142.172508	0.983746	0.736	83	0.806200	79

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81	Peru	0.858896	0.685891	0.710244	54.707007	0.993750	0.734	84	0.803008	82
82	Bosnia and Herzegovina	0.888784	0.684617	0.690064	17.081690	0.998053	0.733	85	0.804585	81
83	Albania	0.909234	0.651099	0.694772	4.342377	0.999510	0.733	85	0.800734	83
84	Armenia	0.860469	0.712539	0.664245	6.182588	0.999300	0.733	85	0.798715	88
85	Ecuador	0.879346	0.683095	0.704509	39.483871	0.995491	0.732	88	0.805640	80
86	Saint Lucia	0.866761	0.678464	0.692043	0.400000	0.999961	0.729	89	0.798703	89
87	Fiji	0.786535	0.798672	0.652030	2.300000	0.999744	0.727	90	0.799946	84
88	Mongolia	0.777096	0.744245	0.706272	18.351520	0.997908	0.727	90	0.799030	87
89	China	0.877773	0.645205	0.729912	8743.590059	0.000000	0.727	90	0.001091	180
90	Thailand	0.855750	0.652467	0.738975	325.313167	0.962801	0.726	93	0.793904	92
91	Libya	0.811704	0.670950	0.755985	57.558477	0.993424	0.724	94	0.799713	85
92	Dominica	0.908652	0.640073	0.695544	0.100000	0.999995	0.724	94	0.797512	90
93	Tunisia	0.862042	0.677385	0.701627	21.405487	0.997559	0.721	96	0.799562	86
94	Colombia	0.849457	0.655684	0.723684	79.558637	0.990908	0.720	97	0.794977	91
95	Saint Vincent and the Grenadines	0.832154	0.686964	0.694687	0.200000	0.999984	0.720	97	0.793834	93
96	Jamaica	0.876199	0.680465	0.650451	8.789880	0.999001	0.719	99	0.788946	97
97	Tonga	0.830580	0.787500	0.593008	0.200000	0.999984	0.717	100	0.789171	96
98	Dominican Republic	0.841592	0.646112	0.721694	20.860197	0.997621	0.715	101	0.791010	94
99	Belize	0.786535	0.743034	0.654458	0.500000	0.999950	0.715	101	0.786406	99
100	Suriname	0.803838	0.635569	0.762977	2.700000	0.999698	0.714	103	0.790092	95

101	Maldives	0.893503	0.594084	0.727256	1.700000	0.999812	0.706	104	0.788202	98
102	Samoa	0.840019	0.715727	0.600517	0.200000	0.999984	0.702	105	0.775155	100
103	Botswana	0.700016	0.662823	0.772615	5.034310	0.999431	0.698	106	0.773669	101
104	Moldova (Republic of)	0.811704	0.706339	0.597526	7.990043	0.999093	0.693	107	0.764880	103
105	Egypt	0.803838	0.632886	0.703186	210.878807	0.975888	0.690	108	0.768672	102
106	Turkmenistan	0.717319	0.634512	0.736036	81.631963	0.990670	0.688	109	0.759006	106
107	Gabon	0.698443	0.633165	0.770059	5.737173	0.999351	0.684	110	0.763787	104
108	Indonesia	0.769231	0.643696	0.692407	537.696847	0.938510	0.684	110	0.753155	107

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109	Paraguay	0.832154	0.611024	0.655042	5.200000	0.999412	0.679	112	0.759572	105
110	Uzbekistan	0.761365	0.685309	0.607160	103.829150	0.988132	0.675	114	0.747996	109
111	Philippines	0.758219	0.622652	0.660320	92.415587	0.989437	0.668	115	0.745239	112
112	El Salvador	0.833727	0.589484	0.649119	6.600000	0.999252	0.666	116	0.751404	108
113	Viet Nam	0.877773	0.603611	0.593682	138.233877	0.984197	0.666	116	0.745922	110
114	South Africa	0.588328	0.728132	0.724710	454.527957	0.948022	0.666	116	0.736551	114
115	Bolivia	0.759792	0.664915	0.612310	19.280313	0.997802	0.662	119	0.745365	111
116	Kyrgyzstan	0.795973	0.711182	0.515981	9.138697	0.998961	0.655	120	0.734963	116
117	Iraq	0.777096	0.513305	0.746498	144.165323	0.983518	0.654	121	0.735640	115
118	Guyana	0.729904	0.580076	0.631068	2.000000	0.999778	0.636	124	0.718923	119
119	Nicaragua	0.863615	0.550300	0.573552	4.700000	0.999469	0.631	125	0.722463	118
120	Morocco	0.849457	0.506783	0.638491	51.700067	0.994094	0.628	126	0.722997	117
121	Namibia	0.704735	0.550895	0.686577	3.559233	0.999600	0.628	126	0.718460	121
122	Guatemala	0.814850	0.511881	0.640224	13.296000	0.998486	0.627	128	0.718588	120
123	Tajikistan	0.777096	0.662463	0.487277	3.162933	0.999645	0.624	129	0.707644	123
124	India	0.755073	0.539609	0.605262	1772.402833	0.797297	0.609	130	0.665898	134
125	Honduras	0.835300	0.522321	0.554855	8.280120	0.999060	0.606	131	0.701274	124
126	Bhutan	0.778669	0.504285	0.645500	0.584220	0.999940	0.605	132	0.709537	122
127	Timor-Leste	0.758219	0.511949	0.601507	0.800000	0.999915	0.595	133	0.695114	125
128	Syrian Arab Republic	0.780242	0.582615	0.499426	35.046933	0.995998	0.594	134	0.689581	126
129	Vanuatu	0.816423	0.542164	0.503492	0.100000	0.999995	0.594	134	0.687083	127
130	Congo	0.665408	0.539546	0.618769	6.576370	0.999255	0.591	136	0.686405	128

131	Equatorial Guinea	0.591474	0.451069	0.808113	4.764143	0.999462	0.587	138	0.681325	130
132	Zambia	0.630801	0.633333	0.546833	3.365000	0.999622	0.586	139	0.683603	129
133	Ghana	0.651251	0.577837	0.551531	13.465906	0.998467	0.579	140	0.674706	132
134	Lao People's Democratic Republic	0.726758	0.491500	0.580945	0.962050	0.999897	0.575	141	0.674918	131
135	Bangladesh	0.811704	0.473421	0.523117	64.294250	0.992653	0.570	142	0.668360	133
136	Cambodia	0.761365	0.484858	0.511177	4.870360	0.999450	0.555	143	0.658999	135

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137	Sao Tome and Principe	0.731477	0.505800	0.509596	0.100000	0.999995	0.555	143	0.658948	136
138	Nepal	0.780242	0.503713	0.474372	4.528810	0.999489	0.548	145	0.657018	137
139	Kenya	0.654397	0.540317	0.501263	14.736000	0.998321	0.548	145	0.648569	138
140	Pakistan	0.726758	0.391107	0.586836	146.755183	0.983222	0.538	147	0.636376	141
141	Myanmar	0.722039	0.401178	0.578590	18.248280	0.997920	0.536	148	0.639501	139
142	Angola	0.508101	0.510955	0.637862	32.224163	0.996321	0.532	149	0.637330	140
143	Swaziland	0.456190	0.575564	0.606487	1.068520	0.999884	0.531	150	0.631688	142
144	Tanzania (United Republic of)	0.707881	0.447906	0.480784	10.145473	0.998846	0.521	151	0.624667	143
145	Nigeria	0.515967	0.464804	0.600903	96.787437	0.988937	0.514	152	0.614421	145
146	Cameroon	0.558440	0.512156	0.503533	8.360217	0.999051	0.512	153	0.615883	144
147	Madagascar	0.709454	0.512829	0.390700	3.306280	0.999629	0.510	154	0.613966	147
148	Zimbabwe	0.589901	0.563084	0.420267	8.561490	0.999028	0.509	155	0.611102	151
149	Mauritania	0.677993	0.388065	0.539628	2.200000	0.999755	0.506	156	0.613803	148
150	Solomon Islands	0.753500	0.448015	0.413039	0.200000	0.999984	0.506	156	0.611069	152
151	Papua New Guinea	0.670127	0.439713	0.483967	6.812227	0.999228	0.505	158	0.614401	146
152	Comoros	0.681139	0.511066	0.404546	0.200000	0.999984	0.503	159	0.612588	149
153	Yemen	0.689004	0.377389	0.537894	22.762409	0.997403	0.498	160	0.611146	150
154	Lesotho	0.468775	0.534552	0.528438	0.800000	0.999915	0.497	161	0.603223	153
155	Togo	0.624508	0.531761	0.378863	1.900000	0.999789	0.484	162	0.595540	154
156	Rwanda	0.695297	0.446293	0.404781	0.900000	0.999904	0.483	163	0.595309	155
157	Haiti	0.673274	0.424489	0.425167	2.700000	0.999698	0.483	163	0.590366	157
158	Uganda	0.605632	0.476185	0.419998	4.000000	0.999549	0.483	163	0.589874	158

159	Benin	0.622935	0.460664	0.433808	5.900000	0.999332	0.480	166	0.593893	156
160	Sudan	0.684285	0.320325	0.549831	16.000000	0.998177	0.479	167	0.588933	159
161	Djibouti	0.660689	0.319884	0.527075	1.000000	0.999892	0.470	168	0.577702	162
162	South Sudan	0.561586	0.401201	0.475729	16.000000	0.998177	0.467	169	0.571921	163
163	Senegal	0.731477	0.333652	0.466101	7.065827	0.999199	0.466	170	0.580640	160
164	Afghanistan	0.635520	0.398869	0.443603	22.081640	0.997481	0.465	171	0.578715	161

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165	Malawi	0.673274	0.477626	0.303824	1.184180	0.999871	0.445	173	0.559064	164
166	Ethiopia	0.693723	0.350342	0.401601	9.844368	0.998881	0.442	174	0.558788	165
167	Gambia	0.632374	0.370644	0.409803	0.500000	0.999950	0.441	175	0.556700	166
168	Congo (Democratic Republic of the)	0.608778	0.491944	0.289667	3.804590	0.999572	0.433	176	0.542653	168
169	Liberia	0.643385	0.430278	0.315043	1.000000	0.999892	0.430	177	0.543420	167
170	Guinea-Bissau	0.553720	0.380327	0.394527	0.400000	0.999961	0.420	178	0.536880	170
171	Mali	0.597766	0.337671	0.417201	1.100000	0.999881	0.419	179	0.538678	169
172	Mozambique	0.552147	0.399513	0.365400	6.513967	0.999262	0.416	180	0.532732	171
173	Sierra Leone	0.486078	0.370779	0.434950	1.100000	0.999881	0.413	181	0.529118	173
174	Guinea	0.610351	0.357185	0.361632	2.500000	0.999721	0.411	182	0.529852	172
175	Burkina Faso	0.608778	0.297176	0.417935	3.100000	0.999652	0.402	183	0.524333	174
176	Burundi	0.577316	0.411446	0.306001	0.200000	0.999984	0.400	184	0.519231	175
177	Chad	0.497090	0.300239	0.458834	0.300000	0.999972	0.392	185	0.511548	176
178	Eritrea	0.687431	0.243876	0.366304	0.500000	0.999950	0.391	186	0.497800	177
179	Central African Republic	0.482932	0.358780	0.265725	0.400000	0.999961	0.350	187	0.463215	179
180	Niger	0.651251	0.221033	0.333297	2.376150	0.999735	0.348	188	0.467983	178

Notes: [a] Source: UNDP Human Development Report

[b] CO_2; (Carbon dioxide emissions for a given country in millions of metric tons: Source: U.S. Energy Information Administration - http://www.eia.gov/beta/international/data/

[c] Authors' computation.

[d] Ranking given here consider the countries in the UNDP (2014) report Accordingly some countries have given the same rank when the HDI takes the same value). Total number of countries in the UNDP report (2014) was 188. Our study has only 180 countries due to availability of CO_2 emission data

[e] Clean Air Adjusted HDI Ranking is out of the 180 countries used in this study.

Computation of Clean Air Adjusted Human Development Index.

Computation of Clean Air Index was based on the information provided in the UNDP Human Development Reports (see calculating the Indices: www.hdr.undp.org/en/content/calculating-indices)

Current computation of HDI consists of three components; Life Expectancy Index, Education Index and GNI Index (Gross National Income). HDI is computed for a given country by taking the geometric mean of these three components. The new index developed in this study incorporates a fourth component and HDI was named as **Clean Air Adjusted HDI**. It is the geometric mean of the said **four components**. With the Clean Air Adjusted HDI it can be clearly seen how existing rankings change for the countries with greater pollution.

The **Clean Air Index** was computed using the country wise carbon dioxide (CO_2) emissions (million metric tones per year) given in US EIA web page for all countries. Clean Air Index was computed as given below. In order to give a lower HDI value for countries with greater pollution one minus CO_2 emission factor (Component in the square bracket which is a value between zero and one). **For the country with highest CO_2 emission this factor is equal to one which makes the clean Air Index 0. For the country with lowest CO_2 emission this factor is equal to zero which results in Clean Air Index equal to one.** Accordingly Clean Air Index is a value between zero and one.

$$Clean\ Air\ Index_i = 1 - \left[\frac{(E_{CO2})_i - \quad (Global\ Min\ CO2)}{(Global\ Max\ CO2) - (Global\ Min\ CO2)}\right]$$

where,

Clean Air Index$_i$ = Clean Air Index for a country i (for a given year)

(E_{CO2}) = CO_2 emission for a country i for a given year

(Global Min CO_2) = minimum CO_2 emission for the year in consideration (country with lowest CO_2 emissions)

(Global Max CO_2) = maximum CO_2 emission for the year in consideration (country with highest CO_2 emissions)

Data Sources

(1) Data related to HDI obtained from UNDP Human Development Report (2014) (http://hdr.undp.org/en/content/human-development-index-hdi (see all 2015 data by indicator year and country)).

(2) CO_2 emission data (2014): U.S. Energy Information Administration - http://www.eia.gov/beta/international/data/