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Wrong Data Manipulation in UN Article on Correlation between Human Development Index (HDI) and Carbon Dioxide Emission

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Abstract: *The Human Development Report 2011 explores the relationship between social and environmental sustainability. Specifically, Chapter 2 of the report analyses the links between three components of the Human Development Index (HDI): income, education, health, and the carbon dioxide emissions arising in each country. This section of the report establishes a poor correlation between non-economic components of HDI and carbon emissions, implying that improvements in health and education sectors are not associated with the rise of carbon emissions. This paper deals with contradictions, calculation errors and judgements in data selection on carbon emission data used for the analysis presented in Chapter 2 of the HDR 2011. Corrections to the calculations of correlation functions between carbon emissions and HDI components are introduced using mathematical methods. Evidence is provided that some HDR statements are erroneous.*
Keywords: *CO_2, data manipulation errors, HDI*

Abbreviations

E	Education component of HDI
H	Health component of HDI
HDI	Human Development Index
HDR	Human Development Report 2011
HDRO	Human Development Report Office
I	Income component of HDI
UNDP	United Nations Development Programme (HDR publisher, see figures)

For A, C, F, M, n, Q, r, S, T, X see (3), (4) and Table 1

I. Introduction

The Human Development Report 2011 (HDR) of the United Nations Development Programme (UNDP) [1] was used for a Conference on Sustainability and Social Justice [2]. In chapter 2 of the HDR, the correlation between carbon dioxide emissions world-wide, and the Human Development Index (HDI) as well as its components are investigated. Carbon dioxide is a green house gas that probably contributes to man-made climate change. While it is uncertain how much carbon dioxide from fossil-fuel combustion contributes to this change, it is certain that sooner or later fossil resources will come to an end. Therefore, for sustainable development fossil-fuel consumption must be reduced and the correlation between carbon dioxide emissions and HDI and components as a measure of development is being investigated. HDI is composed of 3 components: income (I), education (E) and health (H). HDI and its components are all indices with positive values between 0 and 1. All countries are ranked according to their HDI. HDI is the geometrical mean of its components:

(1) $\quad HDI = (I*H*E)^{1/3}$

This is the cubic root of their product. The index for the combined non-income components of HDI should be $(H*E)^{1/2}$, i.e. the square root of their product. Details may be seen in the Technical Notes at the end of HDR [1]. As there are contradictions in figures, text, and obvious errors in data processing in Chapter 2 of HDR [1], the figures were reproduced in this paper with some changes. The publisher of HDR, the Human Development Office (HDRO), was contacted but did not provide requested data or comments. Therefore, their data base was used, and required additional data taken from the figures wherever possible. This will be shown in the following chapter.

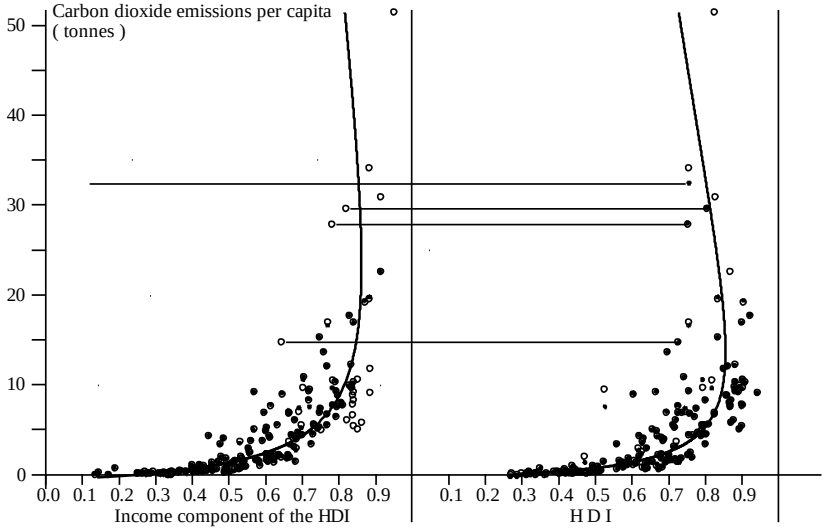
II. Methods

The black dots of Fig. 1 and Fig. 2 in this paper are black and white reproductions from the coloured Fig. 2.1 of chapter 2 of HDR p. 26 [1], showing per capita carbon dioxide emissions over HDI and components. The empty circles in Fig. 1 correspond to data from the database of the Human Development Office (HDRO) in 2007, used by HDR authors. Therefore, the empty circles should coincide with the black dots, which is not

always the case. Small but systematic horizontal and vertical differences between dots and circles existed for HDI on the right-hand side of Fig.1. These were as small as 2 pixels at a horizontal figure extension of over 1000 pixels and might be due to poor graphical precision. Therefore, the dots were shifted by this small amount in this part of Fig. 1 to make them better coincide with the circles from the database. A further justification for this procedure is the fact, that the dots never reach the 0 level of Carbon dioxide emission in the HDR figure, although some of these emissions were rounded down to 0 in the data base. This is evidence for graphical imprecision. The bold curves in Fig. 2 and Fig. 1 including the horizontal lines in the latter, were calculated and drawn here as subsequently discussed. In Fig. 2 of this paper, the right-hand side dots did not coincide with the non-income component of HDI calculated from the data base. Therefore, a multivariate regression analysis was done with those dots, that could be allocated to data in the data base by their carbon dioxide emission values. An equation was found, that matched nearly all of the other dots as shown by the empty circles calculated with this equation, where I is the income component of the HDI:

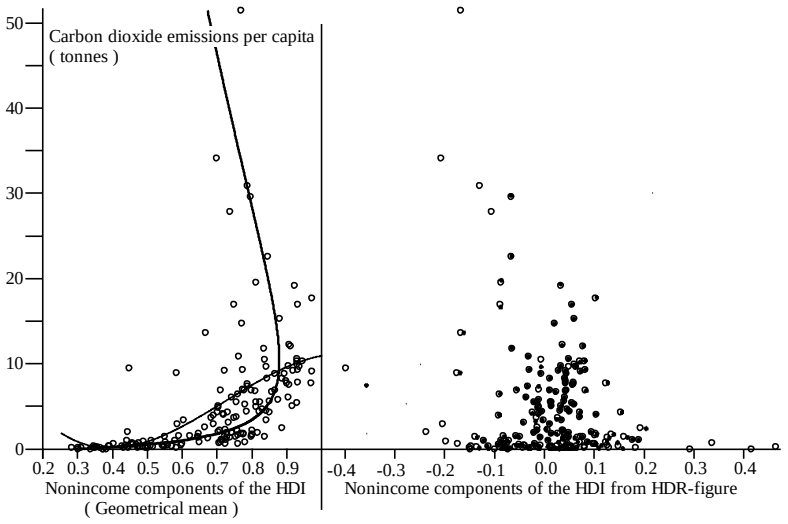
(2) $3.37195 + 1.78187*HDI^{5/6} - 5.46532*I^{1/6}$

In Fig. 2 on the left-hand side the positions of the empty circles were calculated from the data base as the geometrical mean, i. e. the square root of the product of the non-income components. The thin curve therein corresponds to a polynomial of degree 3, also called cubic parabola. Its parameters were found by a regression analysis and this curve will be discussed later.



Source: Adapted from UNDP, 2011, p. 26 and calculations from HDRO database 2007

Fig.1. Carbon dioxide emissions as a function of HDI and its income component



Source: Adapted from UNDP, 2011, p. 26 and calculations from HDRO database 2007

Fig. 2. Carbon dioxide emissions as a function of non-income components of HDI

For better comparison the dot pattern in Fig. 1 and Fig. 2 was transformed using a linearisation method with modified exponential functions that look like (modified) population growth curves over time. The readers who are not interested in the mathematical details may skip the next paragraphs, but should note, that the variables are transformed in order to get straight lines.

An exponential function may be linearised by taking logarithms, which is done here. A transformed variable T is used instead of the carbon dioxide emissions and defined in the following equation: All emissions are given in tonnes per capita and per year.

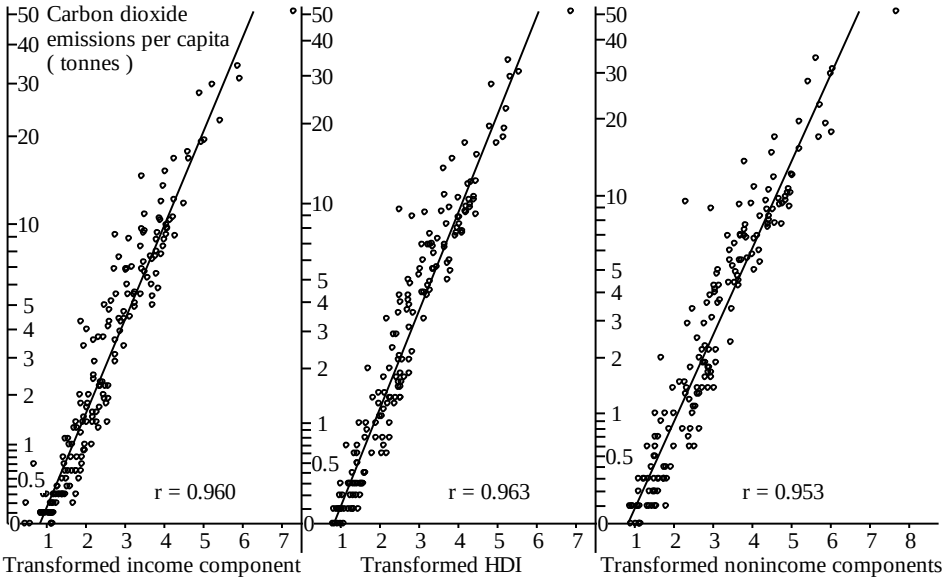
(3) $T = (C+A) / (M+A)$

T Transformed carbon dioxide emission defined by (3)
M Maximum carbon dioxide emission, 51.4 tonnes per capita (Qatar)
C Carbon dioxide emission in tonnes per capita
A Additive small amount of carbon dioxide emission in tonnes per capita (see text)

Parameter A is found by fitting for optimal linearity. A further justification for the introduction of A is the fact that some emissions in the data base are rounded down to 0 and the logarithm of 0 is minus infinity. T is given an exponent n to further improve linearity and the final dependent variable is $\ln(T^n) = n*\ln(T)$, where ln is the natural logarithm. The index HDI and components are also transformed dividing them by $1 - F*T^n$, where F is an appropriate positive factor. Both F and n are fitted for optimal linearity. The transformed index variable may be greater than 1, as can be seen in Fig. 3. The parameters were also used for the bold curves in Fig. 1 and Fig. 2 left-hand side and are shown in Table 1 together with the slope S and the ordinate intercept Q of the straight line. The linear correlation coefficients r for this line were calculated. The justification for this transformation will be discussed later. The linearised equation is:

(4) $\ln(T^n) = n*\ln(T) = S*X/(1 – F*T^n) + Q$

X is here either income I, HDI or non-income component $(H*E)^{1/2}$. S is the calculated value; the slopes in Fig. 3 are adjusted to get equal levels for the minimum and maximum emissions in all three parts of the figure for better comparison. Parameter n changes r only in the transformation of indices.



Source: Calculation from HDRO database 2007

Fig. 3. Carbon dioxide emissions as a function of HDI and components linearised

Table 1. Parameters of calculations

Parameter	Income component	HDI	Non-income components
n	0.057	0.066	0.067
A/tonnes	13.1	7.85	6.4
F	0.87	0.88	0.90
S	0.03875	0.05296	0.05004
Q	-0.24320	-0.32107	-0.33663
r	0.960	0.963	0

Fig. 2.2 of the HDR shows the correlation between the changes of carbon dioxide emissions and changes of HDI and its components. The authors did not give the time interval for the changes nor at what time the data were taken. They give as source the HDRO database for 2007, where these data could not be found. They did not provide the data on request. Their figure is reproduced here as Fig. 4. As the data weren't available, they had to be evaluated graphically for the calculation of the correlation coefficients r . The corresponding sloped lines were calculated and drawn together with the horizontal lines, which will be discussed later.

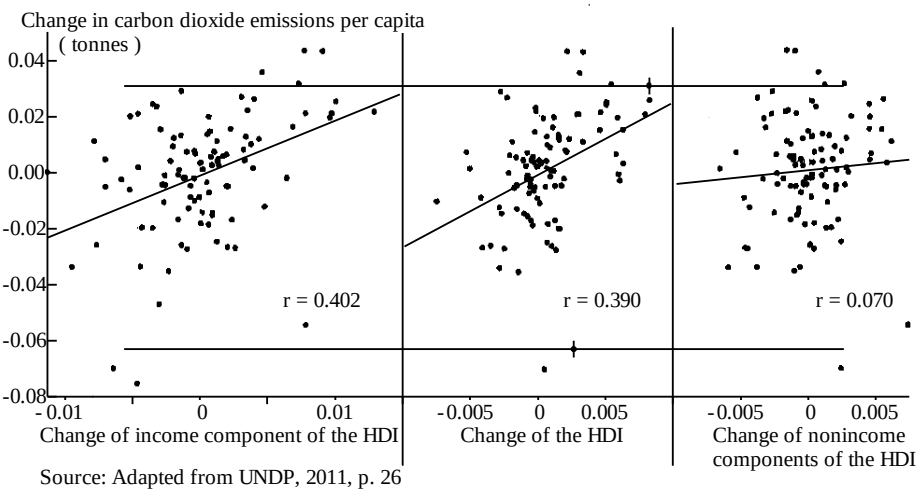


Fig. 4. Change in carbon dioxide emissions as a function of change in HDI and components adapted from HDR [1]

Data for the analysis of the mentioned changes in this paper were selected using the HDRO database corresponding to 1990 and 2008, i.e. for a time interval between these years. The position of the circles in Fig. 5 were calculated with these data, the calculated correlation coefficients r shown and the corresponding lines drawn.

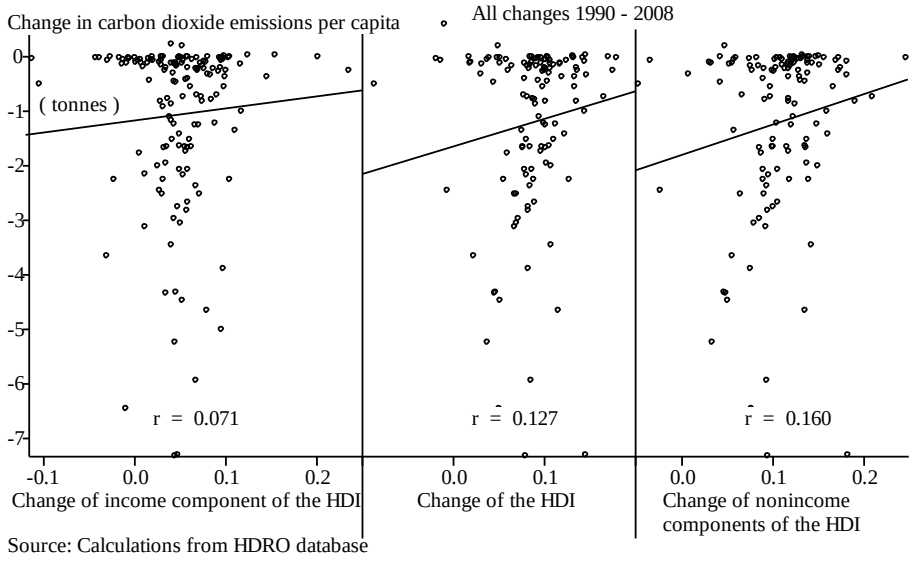


Fig. 5. Change in carbon dioxide emissions as a function of change in HDI and components, 1990-2008

As the used data are no more to be found at their original site in the HDRO data base, they are given here in the appendix. As the non-income components were not in the database , their combined index was calculated indirectly using $(HDI^3/I)^{1/2}$.

III. Discussion

The black dots from the original HDR figure reproduced in Fig. 1 and Fig. 2 of the present paper show some oddities. On the right hand side of Fig. 1 there are some black dots for the HDI, where corresponding black dots for its income component on the left-hand side, at the same emission level, are missing, although the income component is necessary for HDI calculation. These dots are marked with horizontal lines. In HDR's Readers Guide, p. 123, [1] it is mentioned that data had been eliminated because they were unreliable. How is it

possible to calculate a reliable HDI from unreliable or non-existent components? In Fig. 2 on the right-hand side there are some dots at negative combined non-income components. How did the HDR authors get a negative mean from positive components?

The empty circles corresponding with data of HDRO database in Fig. 1 and Fig. 2 right-hand side show, that a lot of data had not been used in the original figure by the HDR authors. They did not provide the data used for their figure on request. On the left-hand side of Fig. 1, two clusters of empty circles corresponding with unused data can be seen. Both are at relatively high income index levels, but one group shows higher and the other lower emissions of carbon dioxide. It is statistically improbable, that unreliable data form clusters in certain areas, if there is a plausibility to be in that area. Let us look, which countries these circles correspond to.

High carbon dioxide emissions arise in Qatar, Kuwait, United Arab Emirates, Bahrain and the state of Trinidad and Tobago. Most of these countries are oil producing countries of the Middle East with a relatively high average income and a lifestyle with high carbon dioxide emissions. Therefore, the plausibility for these countries to be in that area of the figure is a given. Interestingly, Qatar is mentioned in the HDR as the country with the highest carbon dioxide emission, but it does not appear in the diagrams of the HDR (see Fig. 1).

Low carbon dioxide emitters are Andorra, Austria, Denmark, France, Hong Kong, Iceland, Netherlands, Norway, Singapore, Sweden, Switzerland and the United Kingdom. It is doubtful, that they all provide unreliable data. All the mentioned countries are highly industrialised, but have a relatively low carbon dioxide emission due to high environmental standards. Therefore, plausibility is a given as well. In France, a highly industrialised nation, the emission is especially small, because about 75 % of electricity is provided by nuclear power plants.

Are there other reasons why these data have been eliminated? The curves drawn in the original HDR figures, replaced here by the shown bold curves (see below), correspond to polynomials of degree 3, also called cubic parabolas. These show a minimum, an inflexion point and a maximum, in or close to the figure area. An example is shown as the thin curve on the left hand side in Fig. 2. The dot pattern does not show such features. Therefore, such curves are inappropriate here.. On the left hand side of Fig. 1 a cubic parabola involving all available data showed a worse fit than those without the unused data, determining cubic correlation coefficients as an estimate of fitting quality. It is unknown which data were used in the area with crowding dots, because not all dots could be allocated to their corresponding data in this area. However, the impact on the correlation coefficient would be small enough to provide a reliable result for the correlation coefficient, by using all data in this area and omitting only those that could be identified as unused by the HDR authors for comparison with the procedure using all available data. The elimination by the authors may be a case of inappropriate data selection, in order to get a better fit for their inappropriate curve. In this paper all data were taken and appropriate curves selected, although this involves more work than with standard cubic parabolas. The dot patterns in Fig. 1 and the left hand side of Fig. 2 are approximated by the bold curves, which represent modified exponential functions and look like (modified) population growth curves over time. By the way, population growth is also an important factor for development and should not be neglected, but this paper is focussed on the other factors dealt with in Chapter 2 of HDR.

The mentioned additional transformation of HDI and components bends the bold curves in Fig. 1 and 2 a bit to the left at higher carbon dioxide emission levels. Here is the area of mainly high income and high emission countries of the Middle East, that are more or less authoritarian, which reduces HDI, because of deficits in the non-income components. That's why the bending is stronger in HDI and especia;lly non-income components.

The high linear correlation coefficients r linked to the good linearity of the pattern presented in Fig. 3 and Table 1 show that our mathematical modelling is suitable for the data, and that a high correlation between the carbon dioxide emissions and the indices exists in all cases. All correlation coefficients are relatively close to the maximum 1. This mathematical model does not explain the correlation; it was the purpose to show that such a correlation exists in all cases, contrary to the statements in the HDR, as subsequently discussed.

A logarithmic transformation is a standard procedure, while the used modifications are not standard. They are not meant to be introduced for general application, but were only introduced here because it is much easier to compare straight lines than curves. A further advantage of logarithms is the fact that they extend data at small values and squeeze them at high values, leading to a more uniform distribution of the pattern in Fig. 3. For the definition of the income component a similar transformation is used involving also logarithms, see Technical Notes at the end of HDR [1]. This also produces a more uniform distribution, while unfortunately in reality low incomes are crowding and high incomes are rare.

The model might have no real life basis, although such a relationship could approximately be realised when in developing countries industrialisation enforces further industrialisation. This phenomenon was once called industrialising industry in Algeria [3], where this paper's author, working there, could see that focussing mainly on heavy industry did not provide everything the people need. A further requirement for the model to be at least approximately realistic is a proportionality of the indices and time over a certain range, because time is

the independent variable of growth functions. This proportionality cannot exist over a wide range, because time is unlimited and the indices have a maximum of 1. From findings in [4] one can assume such an approximate proportionality between HDI and time. In [4] the authors have also used a semi-logarithmic plot and calculated a correlation coefficient of 0.90 for the relation between carbon dioxide emission and HDI. Their value is slightly smaller than the coefficient obtained in this paper, because in [4] no modifications were done. The emissions are shown on a modified logarithmic scale in Fig. 3 and scales differ slightly for the different components due to the modifications.

The geometrical mean of the non-income components does not match the dots in Fig. 2 right-hand side. (3) does match most dots there , as shown by the circle positions calculated with this equation. Here again, many data have obviously not been used. The equation does not make much sense, and the HDR authors should explain what they have done, when they got negative mean values from positive components whithout any comment.. Fig. 2 left-hand side shows the correct pattern using the geometrical mean of the non-income components for health and education calculated in this paper from the HDRO database.

HDR states: "The association with carbon dioxide emissions per capita is positive and strong for income, positive for the HDI and non-existent for health and education" ([1] p. 26). This is only true for income, the other indices also show a strong correlation proven by the high linear correlation coefficients in Fig. 3 and Table 1. In the HDR the authors reveal that a correlation with HDI does exist, but that it is weaker than with its income component, but there is no significant difference. They are driven by intuition and don't give quantitative results. This intuition may have helped using more data in Fig. 1 right-hand side by them, pulling down their cubic parabola to the area of high HDI and low emission and "weakening" the correlation.

Thus, they state further that: "This result is of course intuitive: activities that emit carbon dioxide into the atmosphere are those linked to the production and distribution of goods. Carbon dioxide is emitted by factories and trucks, not by learning and vaccinations" ([1] p. 25)". This result would be desirable, but it is incorrect. Intuition is telling us that learning or education and vaccination or health systems do not produce carbon dioxide emissions? All students and teachers walk around, use bicycles to reach their wooden schools and universities, windmills or solar panels providing power for their electrical cars and they all have solar heating? And the same is true for pharmaceutical products and buildings, where they are produced in, as well as for medical staff and hospitals? Reality is telling us, that this brave new world does not (yet) exist. So strong was the intuition of the HDR authors, that they even made those statements including Fig. 2.1 in the HDR summary. And in their corresponding press release they state: "While CO_2-emissions have been closely linked with national income growth in recent decades, fossil-fuel consumption does not correspond with other key measures of human development as life expectancy and education." The latter has been shown to be wrong in this paper.

Fig. 2.2 of the HDR shows the correlation between the changes of carbon dioxide emissions and changes of HDI and its components. Fig. 4 reproduces their figure, replacing their standard cubic parabolas by sloping straight lines. Cubic parabolas are completely inappropriate here, because no (such) structure can be recognized in the unstructured dot clouds. Furthermore, the cubic correlation coefficient is nearly equal to the linear one. If the structure were represented by a cubic parabola, the cubic correlation coefficient should be significantly higher than the linear one. Like in Fig. 1, in the centre of Fig. 4 there are HDI values without the necessary components on both sides, marked by horizontal and short vertical lines. Again, the question remains unanswered, how did the authors calculate the HDI without the data of their components? The calculated correlation coefficients r are relatively close to their minimum 0 (r may be -1, which is the maximum for negative correlations, but here all correlations are positive). The precision of the calculation is not very high, because data had to be extracted graphically. Furthermore, it is possible, that dots overlapped. As this is more likely in the centre, where dots are crowding, the impact on the calculated correlation coefficient r should be small. Addition of data in the centre of the dot clouds would not change r significantly.

Statements in the HDR are contradictory: Although the report mentions that a sample of 135 countries for the period between 1970 and 2010 was used for the analysis of carbon dioxide emissions ([1] p. 23), the graphical evaluation method shows approximately 100 used data points. If they were really taken in year 2007 as indicated in the HDR figures, this would exclude a period up to 2010. In the data base for Fig. 1 and Fig. 2 over 170 data sets were available. All these contradictions remain unexplained.

Results of the analysis in this paper are presented in Fig. 5. The sloped lines drawn through dots in both Fig. 4 and Fig. 5 do not mean that a linear relationship exists. Corresponding linear equations are used for calculation of the linear correlation coefficients r in the figures. Looking at the signs of changes, we find a relatively high amount of positive changes for carbon dioxide emissions in Fig. 4, which have been reproduced from HDR and for indices there are a lot of negative changes. This is not the case in Fig. 5, where positive changes for carbon dioxide emissions and negative ones for indices are rare for the period between 1990 and 2008. According to the Kuznets curve, carbon dioxide emissions decrease after an initial period of increase [5]. An increase of the indices is mentioned in HDR: "The average HDI increased 18% between 1990 and 2010 and

41% since 1970" ([1] p. 23). This statement and Fig. 5 contradicts the results shown graphically in Fig. 4 or HDR respectively (see Figure 2.2 of the HDR [1], p. 26). The report states that a correlation between change in carbon dioxide emissions and change in HDI exists ([1] p. 25). However, if this correlation exists at all, it is weak. How this correlation looks like, when all available data are included, is unknown. According to the low correlation coefficients shown in Fig. 5, such a correlation does not exist for the period between 1990 and 2008.

IV. Conclusion

It is important to correct the wrong statements of the HDR here, because it may lead policy makers to wrong decisions on investments. If only the income component of the HDI had a significant ecological footprint, one could think it would be wise limiting the income and investing in education and health systems. Although the latter would be desirable, it would not significantly reduce the impact on carbon dioxide emission. Other or additional measures have to be undertaken for this to happen.

It should also be avoided that such erroneous findings ckkould become "common knowledge", because they are cited by others world-wide without checking, which is already happening, e. g. [6]. This reminds of the famous "high iron content in spinach" based on erroneous laboratory results decades ago, but cited again and again. It was shown mathematically and by reasoning here that the intuition of the HDR authors mislead them. Contrary to them, it was shown that a strong correlation exists between the carbon dioxide emission and the Human Development Index HDI, or its non-income components . The difference in the emissions between the income and the other components found by the HDR authors is due to improper data selection, possibly calculation errors and the use of cubic parabolas as an unsuitable mathematical model. Instead of adapting a better model, they obviously chose the data that fitted best their model. Presumably also calculation errors occurred, which in this case could easily have been detected, as negative mean values were obtained from positive components, which is impossible.

The statement in the HDR [1] that change in carbon dioxide emission is correlated with change of HDI, is doubtful, as it is based on incomplete data, use of cubic parabolas as a completely unsuitable mathematical model, and possibly improper data selection. The authors contradict themselves in their own report, and in the presented paper no such correlation was found with complete and unselected data. It is strongly recommended that the authors review the erroneous part of Chapter 2 of the Human Development Report 2011 [1]and the corresponding parts in the report summary and the press release.

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Appendix: List of used data (Source: HDRO data base)

CO_2: Carbon dioxide emissions/tonnes per capita

Indices×1000 (H Health, E Education, I Income)

- Data not available in data base

	2007				1990			2008		
Country	CO_2	H	E	HDI	I	CO_2	HDI	I	CO_2	HDI	I
Afghanistan	0.0	325	429	363	343	0.8	246	322	0.0	370	342
Albania	1.4	717	889	729	608	8.3	656	526	1.3	733	616
Algeria	4.1	624	823	680	613	11.4	551	587	3.2	686	615
Andorra	6.6	-	954	-	838	-	-	799	6.4	-	841
Angola	2.0	422	465	471	534	1.5	-	464	1.4	476	544
Antigua and Barbuda	5.1	-	822	-	743	17.8	-	676	5.2	-	742
Argentina	4.7	790	871	780	689	12.7	697	612	4.8	786	696
Armenia	1.6	756	846	715	573	3.9	-	-	1.8	719	583
Australia	17.7	978	967	922	828	63.7	873	779	19.0	924	831
Austria	8.3	829	948	870	840	28.8	790	793	8.1	876	842
Azerbaijan	3.7	-	786	-	592	21.7	-	-	5.4	-	612
Bahamas	6.4	671	860	770	792	28.0	-	778	6.4	771	789
Bahrain	29.6	737	860	804	819	88.4	721	754	29.0	806	821
Bangladesh	0.3	400	752	478	363	0.5	352	277	0.3	484	370
Barbados	4.9	743	886	791	751	14.5	-	720	5.3	792	751
Belarus	6.9	776	778	738	665	35.1	-	-	6.5	744	680
Belgium	9.7	870	939	880	834	39.7	811	791	9.9	882	834
Belize	1.4	653	869	692	583	6.2	651	540	1.4	695	585
Benin	0.4	355	544	414	369	0.5	316	342	0.5	419	373
Bhutan	0.9	-	721	-	537	0.9	-	415	1.1	-	539
Bolivia	1.4	727	716	645	515	3.0	560	476	1.3	651	522
Bosnia and Herzegovina	7.6	712	869	725	614	4.4	-	-	8.3	730	622
Botswana	2.9	679	508	618	684	5.8	594	607	2.5	624	687
Brazil	1.9	646	822	700	644	5.1	600	608	2.1	705	650
Brunei Darussalam	19.5	726	906	835	883	91.6	784	888	27.0	834	878
Bulgaria	6.8	789	831	758	665	31.9	698	607	6.7	765	678
Burkina Faso	0.1	172	529	313	338	0.2	-	283	0.1	321	341
Burundi	0.0	310	452	289	172	0.2	250	221	0.0	301	182
Cambodia	0.3	501	650	508	403	0.2	-	-	0.3	513	408
Cameroon	0.3	479	471	459	428	0.5	427	428	0.3	466	428
Canada	16.9	908	954	900	841	59.6	857	796	16.4	903	841
Cape Verde	0.6	427	840	560	490	0.9	-	398	0.6	563	495
Central African Republic	0.1	303	403	323	277	0.2	310	300	0.1	327	273
Chad	0.0	203	448	313	337	0.1	-	300	0.0	316	329
Chile	4.3	781	925	789	680	9.9	698	592	4.4	796	690
China	5.0	599	829	656	568	7.7	490	345	5.2	665	580
Colombia	1.3	636	833	691	623	6.0	594	582	1.5	697	625
Comoros	0.2	368	624	428	342	0.5	-	357	0.2	429	340
Congo	0.4	521	565	512	456	1.8	502	481	0.6	520	472
Congo Democratic Rep.	0.0	338	432	271	136	0.4	289	242	0.0	270	129
Costa Rica	1.8	649	928	735	659	3.5	656	587	1.8	737	661
Côte d'Ivoire	0.3	297	515	388	382	1.7	361	397	0.3	392	383
Croatia	5.5	769	881	791	731	13.5	-	-	5.3	795	733
Cuba	2.4	853	920	759	557	11.5	677	523	2.8	767	563
Cyprus	10.5	754	929	819	784	25.1	747	747	9.9	827	788
Czech Republic	12.0	928	897	861	768	46.6	-	-	11.3	864	770
Denmark	9.2	917	917	890	839	36.0	809	790	8.4	891	837
Djibouti	0.6	284	574	416	440	2.6	-	-	0.6	421	444
Dominica	1.7	668	901	719	618	3.1	-	577	1.9	722	622
Dominican Republic	2.2	605	827	672	606	4.8	577	513	2.2	677	613
Ecuador	2.2	661	868	702	604	6.0	636	557	2.0	714	615
Egypt	2.5	536	824	626	555	5.1	497	493	2.6	633	562
El Salvador	1.0	630	810	668	586	1.9	524	513	1.0	668	589
Equatorial Guinea	9.5	427	472	526	721	1.3	-	419	7.3	537	759
Eritrea	0.1	-	628	-	251	-	-	-	0.1	-	236
Estonia	15.3	916	846	834	747	60.1	717	661	13.6	832	740

Appendix continued	2007				1990			2008		
Country	CO_2	H	E	HDI	I	CO_2	HDI	I	CO_2	HDI	I
Ethiopia	0.1	229	580	337	288	0.2	-	245	0.1	348	302
Fiji	1.8	768	768	681	535	4.1	624	503	1.5	684	536
Finland	12.2	880	934	881	833	37.5	794	776	10.7	883	834
France	6.0	855	959	877	822	25.7	777	787	6.1	879	821
Gabon	1.4	644	645	656	681	24.3	605	702	1.7	660	679
Gambia	0.3	313	587	399	346	0.7	317	340	0.3	408	355
Georgia	1.4	836	837	724	543	10.5	-	-	1.2	722	544
Germany	9.6	929	942	901	835	44.2	795	796	9.6	902	836
Ghana	0.4	537	667	508	365	0.9	418	310	0.4	519	373
Greece	8.8	852	938	860	796	26.2	766	742	8.8	862	798
Grenada	2.3	-	872	-	620	4.6	-	554	2.4	-	621
Guatemala	1.0	423	792	565	538	2.1	462	499	0.9	568	539
Guinea	0.1	243	508	337	310	0.6	-	292	0.1	340	310
Guinea-Bissau	0.2	302	421	345	323	0.9	-	352	0.2	346	322
Guyana	2.0	648	763	619	479	5.7	489	335	2.0	622	480
Haiti	0.3	395	642	443	343	0.5	397	384	0.3	445	341
Honduras	1.2	553	820	613	507	1.9	513	457	1.2	619	510
Hong Kong, China (SAR)	5.8	787	971	870	862	17.8	786	779	5.5	885	867
Hungary	5.6	857	845	809	732	21.9	706	683	5.5	811	732
Iceland	7.8	898	966	899	838	29.6	807	790	7.1	895	821
India	1.4	436	694	523	471	2.9	410	359	1.5	527	475
Indonesia	1.8	557	753	591	492	3.0	481	430	1.8	598	502
Iran Islamic Republic	6.9	616	819	694	663	14.7	534	592	7.3	699	665
Iraq	3.4	483	754	558	477	10.4	-	-	3.4	564	489
Ireland	10.3	954	938	909	840	32.3	782	729	9.8	909	833
Israel	9.3	906	956	882	792	27.2	802	739	5.4	882	792
Italy	7.7	840	966	869	810	27.5	764	781	7.5	871	806
Jamaica	5.2	742	821	717	604	12.3	637	571	4.5	724	607
Japan	9.9	873	989	894	829	34.8	827	798	9.5	896	828
Jordan	3.7	686	834	685	561	11.7	591	493	3.5	692	567
Kazakhstan	14.7	827	721	727	644	58.3	-	-	15.3	729	643
Kenya	0.3	552	543	486	383	0.9	456	375	0.3	493	381
Kiribati	0.3	-	741	-	503	1.1	-	501	0.3	-	504
Korea Dem. People's Rep.	-	-	766	-	-	44.6	-	-	3.3	-	-
Korea Republic	10.3	918	942	881	791	20.7	742	678	10.6	886	795
Kuwait	34.1	574	854	756	882	69.7	712	848	26.3	757	882
Kyrgyzstan	1.1	714	737	605	420	9.0	-	-	1.1	611	429
Lao People's Dem. Rep.	0.3	419	721	500	415	0.2	376	323	0.3	507	421
Latvia	3.4	860	824	800	724	18.7	693	661	3.4	803	721
Lebanon	3.6	687	818	721	665	11.2	-	607	4.1	726	675
Lesotho	-	492	401	429	401	-	470	388	-	436	405
Liberia	0.2	420	535	319	144	0.8	-	-	0.1	328	151
Libyan Arab Jamahiriya	9.3	704	850	755	719	33.9	-	-	9.3	759	718
Liechtenstein	-	-	932	-	955	-	-	886	-	-	945
Lithuania	4.5	872	812	803	730	22.0	-	-	4.5	806	735
Luxembourg	22.6	766	935	868	914	95.2	788	860	21.9	867	904
Macedonia f. Yug. Rep.	5.5	670	854	712	632	20.4	-	-	5.8	725	640
Madagascar	0.1	475	716	476	316	0.3	-	329	0.1	483	322
Malawi	0.1	384	488	367	264	0.2	291	242	0.1	377	273
Malaysia	7.0	713	841	746	692	11.5	631	595	7.7	750	694
Maldives	2.9	544	873	640	553	2.6	-	-	3.0	648	560
Mali	0.0	244	470	338	335	0.2	204	270	0.0	346	338
Malta	6.7	792	926	826	768	23.0	753	713	6.3	829	771
Marshall Islands	1.9	689	800	-	-	3.7	-	-	1.6	-	-
Mauritania	0.6	353	592	442	414	5.0	353	400	0.6	446	416
Mauritius	3.1	645	833	714	677	5.1	618	588	3.1	718	682

Appendix continued	2007				1990			2008		
Country	CO_2	H	E	HDI	I	CO_2	HDI	I	CO_2	HDI	I
Mexico	4.4	695	884	755	699	16.8	649	657	4.4	761	700
Micronesia Fed. States	0.6	689	761	637	494	-	-	-	0.6	636	488
Moldova Republic	1.3	716	760	638	478	17.4	-	-	1.3	644	489
Monaco	-	-	973	-	-	-	-	-	-	-	-
Mongolia	4.0	698	742	631	485	16.6	540	426	4.1	641	496
Montenegro	-	802	852	767	660	-	-	-	3.1	771	671
Morocco	1.5	433	805	565	518	3.5	435	466	1.5	570	524
Mozambique	0.1	214	452	299	277	0.3	200	189	0.1	304	284
Myanmar	0.2	388	685	459	364	0.4	298	175	0.3	468	376
Namibia	1.5	608	636	607	580	0.0	564	530	1.9	613	582
Nauru	10.8	-	937	-	-	52.9	-	-	14.2	-	-
Nepal	0.1	340	742	437	332	0.1	340	287	0.1	443	336
Netherlands	10.6	911	947	902	851	41.1	835	797	10.5	904	847
New Zealand	7.7	994	947	903	783	24.4	828	745	7.8	904	780
Nicaragua	0.8	508	833	577	453	2.3	473	416	0.8	583	461
Niger	0.1	155	517	273	254	0.5	193	270	0.1	282	264
Nigeria	0.7	442	473	441	409	1.8	-	364	0.6	446	416
Norway	9.1	992	951	942	886	27.1	844	823	10.5	941	885
Occ. Palestinian Terr.	0.6	-	822	-	468	-	-	466	0.5	-	462
Oman	13.6	535	835	697	759	20.6	-	718	16.4	702	774
Pakistan	1.0	374	702	493	455	2.2	399	411	0.9	495	455
Palau	9.6	890	797	793	703	57.6	-	-	10.4	781	666
Panama	2.2	735	874	752	661	4.8	660	581	2.0	758	673
Papua New Guinea	0.5	324	651	447	424	1.9	368	400	0.3	452	429
Paraguay	0.7	613	815	643	533	2.0	572	532	0.7	650	539
Peru	1.6	692	837	704	602	3.6	612	540	1.4	712	616
Philippines	0.8	672	753	630	494	2.7	571	452	0.9	635	498
Poland	8.3	814	875	800	718	33.5	-	-	8.3	804	727
Portugal	5.5	716	923	798	768	16.3	708	729	5.3	802	767
Qatar	51.4	649	911	825	950	92.4	743	868	53.5	825	965
Romania	4.4	805	836	767	670	25.1	700	624	4.4	778	682
Russian Federation	10.8	778	745	742	704	51.0	-	-	12.1	748	711
Rwanda	0.1	376	532	401	323	0.3	232	286	0.1	411	334
Saint Kitts and Nevis	5.5	-	823	-	698	5.9	-	632	4.9	-	710
Saint Lucia	2.2	-	847	-	637	4.4	-	601	2.3	-	635
St. Vincent + Grenadines	2.0	-	812	-	630	2.7	-	536	1.9	-	631
Samoa	0.8	750	811	684	525	2.8	-	523	0.9	688	532
San Marino	-	-	968	-	-	-	-	-	-	-	-
Sao Tome and Principe	0.8	443	689	496	399	2.1	-	-	0.8	496	402
Saudi Arabia	16.9	669	836	755	770	48.5	693	762	17.2	760	773
Senegal	0.5	367	600	445	400	1.5	365	375	0.4	451	402
Serbia	-	775	851	754	652	-	-	-	5.1	760	659
Seychelles	7.3	745	834	775	749	5.8	-	698	8.1	773	738
Sierra Leone	0.3	294	407	319	271	0.3	241	258	0.3	325	277
Singapore	11.8	729	954	850	884	57.1	-	788	7.0	855	883
Slovakia	6.9	871	862	825	748	30.7	747	691	7.0	831	758
Slovenia	7.5	892	921	868	795	23.3	-	-	8.5	875	800
Solomon Islands	0.4	427	730	515	440	1.9	-	-	0.4	514	434
Somalia	0.1	-	477	-	-	0.0	-	-	0.1	-	-
South Africa	8.9	695	491	604	645	33.4	615	622	8.8	608	649
Spain	8.0	846	953	866	806	21.6	749	756	7.4	871	805
Sri Lanka	0.6	673	857	673	528	0.8	583	430	0.6	676	533
Sudan	0.3	239	634	395	406	0.8	298	315	0.3	399	412
Suriname	4.8	636	780	668	600	16.5	-	567	4.7	672	607
Swaziland	0.9	564	423	507	547	1.8	526	517	1.0	512	546
Sweden	5.4	900	959	899	841	21.9	816	786	5.3	900	841
Appendix continued	2007				1990			2008		

Country	CO_2	H	E	HDI	I	CO_2	HDI	I	CO_2	HDI	I
Switzerland	5.0	860	973	893	852	23.1	833	836	5.3	892	841
Syrian Arab Republic	3.6	535	872	628	530	10.8	548	480	3.4	629	533
Tajikistan	1.1	698	729	588	399	14.2	-	-	0.5	597	410
Tanzania United Rep.	0.1	445	552	440	347	0.3	352	304	0.1	448	355
Thailand	4.3	584	844	670	610	6.5	566	526	4.3	672	612
Timor-Leste	0.2	371	641	487	487	-	-	273	0.2	505	534
Togo	0.3	461	562	424	294	0.7	368	306	0.2	426	293
Tonga	1.7	783	817	698	532	3.0	649	491	1.7	700	534
Trinidad and Tobago	27.8	701	776	752	781	50.8	676	659	37.3	751	769
Tunisia	2.3	617	849	681	602	5.9	542	524	2.5	688	607
Turkey	3.9	572	833	688	684	9.4	558	622	3.9	691	683
Turkmenistan	9.2	739	703	666	569	26.5	-	-	9.5	671	580
Tuvalu	-	-	724	-	-	-	-	-	-	-	-
Uganda	0.1	446	501	420	331	0.2	299	235	0.1	430	339
Ukraine	6.9	851	750	725	597	43.5	707	632	7.0	729	601
United Arab Emirates	30.9	702	881	827	915	107.6	690	871	34.6	835	918
United Kingdom	8.8	799	938	856	837	36.8	778	781	8.5	860	838
United States	19.1	933	913	905	871	69.7	870	825	17.3	907	869
Uruguay	1.9	753	887	764	667	4.7	686	609	2.5	769	678
Uzbekistan	4.3	714	748	619	445	19.4	-	-	4.6	624	457
Vanuatu	0.5	-	786	-	515	1.7	-	512	0.4	-	526
Venezuela Bolivar. Rep.	6.0	649	846	720	680	22.7	629	651	6.0	730	683
Viet Nam	1.3	488	856	575	454	1.2	435	307	1.5	580	461
Yemen	1.0	282	689	438	432	2.9	-	-	1.0	444	432
Zambia	0.2	475	414	405	338	1.1	394	346	0.1	413	347
Zimbabwe	0.7	554	409	350	189	5.8	425	266	0.7	338	161