A Note on Human Development Indices with Income Equalities

SK Mishra
Department of Economics
North-Eastern Hill University
Shillong (India)

Introduction: Sarker et al. (2006) in their paper argued that Human Development Index (HDI) should include income equality measures (EQ) also in addition to the three measures of life expectancy (LE), education (ED) and per capita gross domestic product at the purchasing power parity with the US $ (PCI), conventionally incorporated into it. They computed the per capita income distribution-adjusted composite index (DAPCHDI) of human development and showed that the ranking of countries on the basis of this type of HDI (that includes income distribution as one of the component indices) differed substantially from the ranking calculated in the *Human Development Reports* (HDR) of UNDP (published annually). They suggested, therefore, that within-country income distribution should be given its due importance in international comparison of countries.

Sarker et al. used data on life expectancy, educational index and per capita income from the Human Development Report of UNDP for 2004. From the information on Gini coefficients of income distribution available in the HDR for various years they also constructed an index to measure equality in distribution of per capita income. They used the Gini coefficients data over a span of 13 years (1990–2002). Under the constraints of data availability on income distribution, they chose 125 countries for construction of distribution-augmented HDI. The indices were subjected to the principal component analysis (PCA) and two composite indices of Human Development, the one (PCHDI) without incorporating equality index and the other (DAPCHDI) with its inclusion were obtained. They noted, among other points, the following:

- Against the equal HDR weights for every index ($1/3 \approx 0.333$), the principal component weights for life expectancy, education and per capita income in the PCHDI were 0.36, 0.32 and 0.32 respectively. These weights were 0.30, 0.25 and 0.25 for the DAPCHDI. Since the latter also includes the equality index, the residual (0.20) weight was assumed by this additional variable. These weights sum up to unity.
- Due to change in weights assigned to different indices to make their linear aggregate (the composite index of HDI), the ranks of different countries in PCHDI and DAPCHDI were notably different.

The Present Study: Our objective here is twofold. First, we re-compute the DAPCHDI with the data given by Sarker et al. in their paper to compare our composite index with theirs. The HDR-2005 or the HDR-2006 adds little to the HDR-2004 database. Secondly, we compute a slightly different DAPCHDI by a new method, which, unlike the principal component analysis that aims at maximizing the sum of squared coefficients of correlation between the composite index and the constituent variables, maximizes, instead, the sum of absolute coefficients of correlation between the composite index and the constituent variables. We call them $NHDI_2$ and $NHDI_1$ respectively.

Haq (2003) noted that there is no *a priori* rationale for assigning different weights to different constituent indices. Each dimension of development is important, but the importance of each dimension may be different for developed and developing countries. Hence, he pleaded for equal weights on the principle of insufficient reason to discriminate among the constituent indices. In a hurry to abandon income as a sole measure of development, the protagonists of human development resorted to extreme pragmatism. On the other hand, the PCA, a blindly empiricist method, has a tendency to undermine poorly correlated variables and instead favor highly correlated variables to make a composite index (Mishra, 2007-a and 2007-b). A comparison of the principal component index with the one constructed by maximizing the sum of absolute correlation coefficients has revealed that the latter is an inclusive index (giving due weights to poorly correlated variable too) while the principal component index is largely elitist, favoring highly correlated variables and undermining the poorly correlated ones (Mishra, 2007-c).

A Formal Description: It has been mentioned that the PCA makes a composite index such that the sum of squared coefficients of correlation between the composite index and the constituent variables is maximized. On the other hand, our new (inclusive) method maximizes the sum of absolute coefficients of correlation between the composite index and the constituent variables. Formally, if $I = Xw = \sum_{j=1}^{m} w_j x_{ij};\ i = 1,2,...,n$ is the composite index, $x_j;\ j = 1,2,...,m$ are the constituent variables (such as the life expectancy index, educational index, etc) and $r(I, x_j)$ is the coefficient of correlation between I and x_j then,

(1). I (PCA) is obtained by maximizing $\sum_{j=1}^{m} r^2(I, x_j)$ *or* $\sum_{j=1}^{m} \left| r(I, x_j) \right|^2$ *or* $\left[\sum_{j=1}^{m} \left| r(I, x_j) \right|^2 \right]^{1/2}$

(2). I (new method) is obtained by maximizing $\sum_{j=1}^{m} \left| r(I, x_j) \right|$

These measures relate to the Minkowski norm, L_p, for p=2 and p=1 respectively. The I (PCA) may be obtained by maximizing the above measure directly by some suitable method of non-linear optimization or by the traditional method (finding largest eigenvalue and the associated eigenvector of the correlation matrix of constituent variables, etc). However, I (new method) must be obtained by direct maximization.

Findings: We have maximized the quantities directly (Mishra, 2007-d) by the Differential Evolution method of global optimization to obtain I (PCA) and I (new method) from the four indices, namely life expectancy (LE), education (ED), per capita income (PCI) and equality index (EQ). The data for 125 countries, given by Sarker et al. in their paper, are reproduced in Table-4 here. We also reproduce the HDR-2004 ranks (R_1), PCHDI ranks (R_2) and values as well as the DAPCHDI ranks (R_3) and values obtained by Sarker et al. It may further be noted that computation of I (PCA) by the traditional method gives the same correlation coefficients (loadings) to variables (LE, ED, PCI and EQ) as does the direct optimization method.

The HDI indices computed by us are $NHDI_2$ (principal component) and $NHDI_1$ (new method) and the ranks obtained by different countries are R_4 and R_5 respectively.

These HDI indices too are presented in Table-4. Note that ranks are based on more accurate $NHDI_2$ and $NHDI_1$ figures than what are presented in the Table-4.

In our analysis, the constituent indices of HDI obtain different weights and are differently correlated with their composite HDI indices. These weights and correlation coefficients are given in Table-1 and Table-2 respectively.

Table-1: Weights assigned to the Constituent Indices by Different Methods				
Indices	LE	ED	PCI	EQ
DAPCHDI	0.30	0.25	0.25	0.20
$NHDI_2$	0.270909751	0.275588551	0.289481714	0.164019853
$NHDI_1$	0.239643184	0.258695275	0.265657700	0.236003815

Table-2: Correlation of Composite HDI Indices with Different Constituent Indices						
Index	LE	ED	PCI	EQ	SAR	SSR
$NHDI_2$	0.923635411	0.870389039	0.890306269	0.567829911	3.25216063	2.72575551
$NHDI_1$	0.914036295	0.845974366	0.865869176	0.639601336	3.26548117	2.70995428
SAR=Sum of Absolute correlation coefficients; SSR=Sum of Squared correlation coefficients						

It may be noted that $NHDI_1$ trades off SSR only slightly to assign higher weights to EQ index. In exchange, the weights of LE, ED and PCI are reduced. Overall, $NHDI_1$ weights are more egalitarian than the $NHDI_2$ weights. Finally, in the Table-3 below we present the matrix of correlation coefficients (based on figures in Table-4) among and across different ranks and composite HDI measures.

Table-3: Correlation Matrix of Different Ranks and HDI Indices obtained by Different Methods									
Ranks/ HDI Indices	Ranks obtained by Different Methods					HDI Indices obtained by Different Methods			
	R1	R2	R3	R4	R5	PCHDI	DA PCHDI	$NHDI_2$	$NHDI_1$
R1	1.00000	0.99969	0.96199	0.97512	0.95372	-0.97103	-0.95206	-0.96446	-0.94855
R2	0.99969	1.00000	0.96289	0.97568	0.95443	-0.97105	-0.95320	-0.96515	-0.94960
R3	0.96199	0.96289	1.00000	0.99736	0.99878	-0.94587	-0.98259	-0.98089	-0.98573
R4	0.97512	0.97568	0.99736	1.00000	0.99478	-0.95589	-0.98075	-0.98235	-0.98284
R5	0.95372	0.95443	0.99878	0.99478	1.00000	-0.93923	-0.98202	-0.97900	-0.98633
PCHDI	-0.97103	-0.97105	-0.94587	-0.95589	-0.93923	1.00000	0.97141	0.98302	0.96251
DAPCHDI	-0.95206	-0.95320	-0.98259	-0.98075	-0.98202	0.97141	1.00000	0.99783	0.99865
$NHDI_2$	-0.96446	-0.96515	-0.98089	-0.98235	-0.97900	0.98302	0.99783	1.00000	0.99569
$NHDI_1$	-0.94855	-0.94960	-0.98573	-0.98284	-0.98633	0.96251	0.99865	0.99569	1.00000

Concluding Remarks: The Human Development Reports assign subjective (or arbitrary) weights to indices of life expectancy, education, and income. Inclusion of equality index to HDI naturally raises the question as to the weight to be assigned to it. It is also required to reduce the weights assigned to other indices. An attempt may be made to obtain weights by the principal component analysis. However, the principal component analysis has a tendency to undermine the variables with weaker correlation coefficients. It may be elitist in favoring the highly correlated indices. Variance or explanatory power of a composite index cannot be the sole guide to assign weights. Representation of individual indices in the composite HDI also matters. The HDR has taken an extreme stand of assigning equal weights to all indices and suffers from an excessive bias to pragmatism. However, the new method of obtaining weights and constructing an HDI

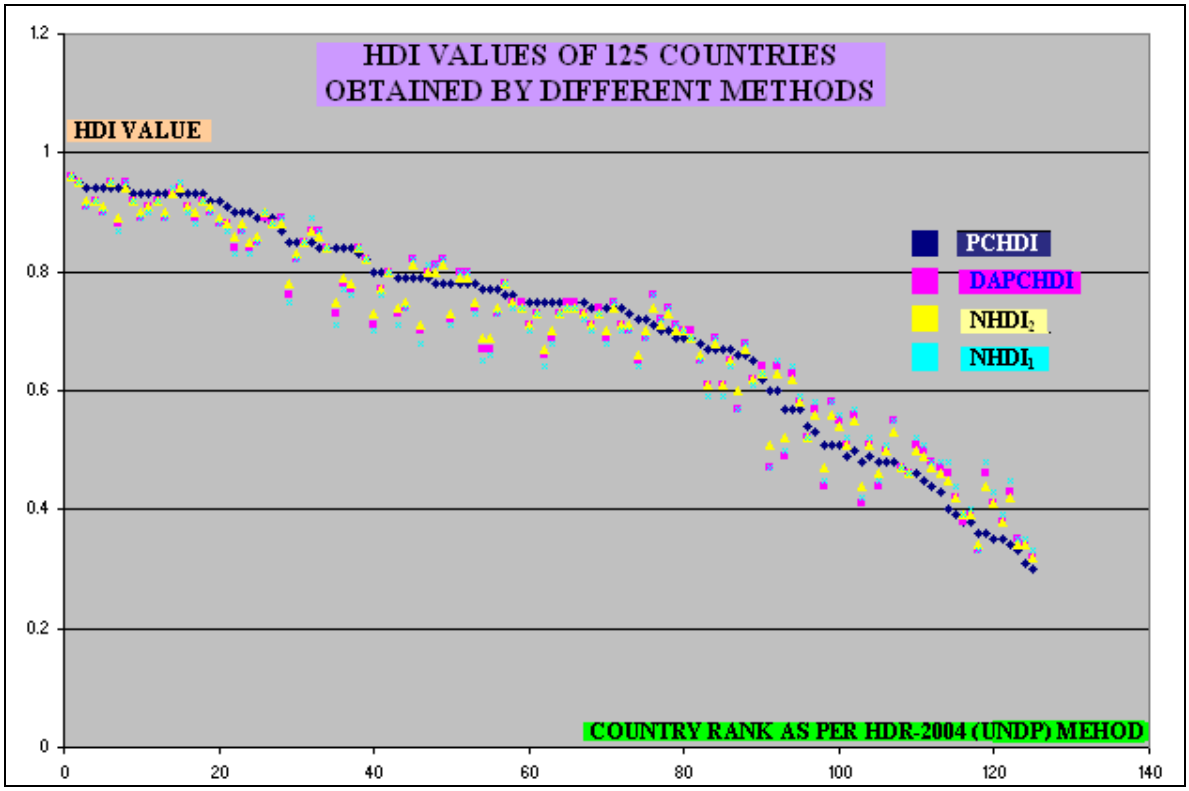
suggested by us is inclusive in nature, which takes care of weakly correlated indices also and gives them proper representation in the composite Human Development Index.

Table-4: Composite Indices of Human Development in Select Countries obtained by Different Methods

Select Countries	Ranks by Different Methods					Human Development Indices: Different Aspects				Composite Indices of HDI			
	R_1	R_2	R_3	R_4	R_5	LE	ED	PCI	EQ	PC HDI	DAPC HDI	New Indices	
												$NHDI_2$	$NHDI_1$
Norway	1	1	1	1	1	0.90	0.99	0.99	0.96	0.96	0.96	0.96	0.96
Sweden	2	2	2	2	2	0.92	0.99	0.93	0.98	0.95	0.95	0.95	0.95
Canada	3	3	11	11	11	0.90	0.98	0.95	0.81	0.94	0.91	0.92	0.91
Netherlands	4	6	10	8	10	0.89	0.99	0.95	0.82	0.94	0.92	0.92	0.92
Australia	5	4	14	13	14	0.90	0.99	0.94	0.76	0.94	0.90	0.91	0.90
Belgium	6	5	3	3	3	0.90	0.99	0.94	0.98	0.94	0.95	0.95	0.95
United_States	7	7	23	20	26	0.87	0.97	0.98	0.64	0.94	0.88	0.89	0.87
Japan	8	8	4	4	5	0.94	0.94	0.93	0.98	0.94	0.95	0.94	0.95
Luxembourg	9	10	9	10	9	0.89	0.91	1.00	0.86	0.93	0.92	0.92	0.92
Ireland	10	14	18	16	17	0.86	0.96	0.98	0.75	0.93	0.89	0.90	0.89
Switzerland	11	9	12	12	12	0.90	0.95	0.95	0.81	0.93	0.91	0.91	0.90
Austria	12	11	8	9	8	0.89	0.96	0.95	0.87	0.93	0.92	0.92	0.92
United_Kingdom	13	12	17	17	19	0.88	0.99	0.93	0.74	0.93	0.89	0.90	0.89
Finland	14	13	6	6	6	0.88	0.99	0.93	0.94	0.93	0.93	0.93	0.94
Denmark	15	15	5	5	4	0.86	0.98	0.96	0.99	0.93	0.94	0.94	0.95
France	16	16	13	14	13	0.90	0.96	0.93	0.81	0.93	0.91	0.91	0.90
New_Zealand	17	17	19	19	21	0.89	0.99	0.90	0.74	0.93	0.89	0.90	0.88
Germany	18	18	7	7	7	0.89	0.95	0.94	0.91	0.93	0.92	0.92	0.92
Spain	19	19	15	15	15	0.90	0.97	0.90	0.82	0.92	0.90	0.91	0.90
Italy	20	20	21	21	23	0.89	0.93	0.93	0.74	0.92	0.88	0.89	0.88
Israel	21	21	24	23	24	0.90	0.94	0.88	0.76	0.91	0.88	0.88	0.87
Singapore	22	23	30	29	32	0.88	0.91	0.92	0.61	0.90	0.84	0.86	0.83
Greece	23	22	26	25	27	0.89	0.95	0.87	0.76	0.90	0.87	0.88	0.87
Hong_Kong_China_(SAR)	24	24	32	30	33	0.91	0.86	0.93	0.59	0.90	0.84	0.85	0.83
Portugal	25	25	28	27	28	0.85	0.97	0.87	0.69	0.89	0.85	0.86	0.85
Slovenia	26	26	16	18	16	0.85	0.96	0.87	0.91	0.89	0.89	0.90	0.90
Korea_Rep_of	27	27	22	24	22	0.84	0.97	0.86	0.84	0.89	0.88	0.88	0.88
Czech_Republic	28	28	20	22	18	0.84	0.92	0.84	0.97	0.87	0.89	0.88	0.89
Argentina	29	29	47	45	49	0.82	0.96	0.78	0.40	0.85	0.76	0.78	0.75
Estonia	30	30	34	34	34	0.78	0.98	0.80	0.72	0.85	0.82	0.83	0.82
Poland	31	31	29	31	29	0.81	0.96	0.78	0.84	0.85	0.85	0.85	0.85
Hungary	32	32	25	26	20	0.78	0.95	0.82	1.00	0.85	0.87	0.87	0.89
Slovakia	33	33	27	28	25	0.81	0.91	0.81	0.96	0.84	0.87	0.86	0.87
Lithuania	34	35	33	33	31	0.79	0.96	0.77	0.83	0.84	0.84	0.84	0.84
Chile	35	34	60	49	64	0.85	0.90	0.77	0.30	0.84	0.73	0.75	0.71
Uruguay	36	36	43	43	44	0.84	0.94	0.73	0.56	0.84	0.78	0.79	0.77
Costa_Rica	37	37	45	44	47	0.88	0.87	0.75	0.52	0.84	0.77	0.78	0.76
Croatia	38	38	31	32	30	0.82	0.90	0.77	0.89	0.83	0.84	0.84	0.84
Latvia	39	39	36	35	35	0.76	0.95	0.75	0.82	0.82	0.82	0.82	0.82
Mexico	40	40	66	63	72	0.81	0.85	0.75	0.35	0.80	0.71	0.73	0.70
Trinidad_and_Tobago	41	41	46	47	45	0.77	0.87	0.76	0.65	0.80	0.77	0.77	0.76
Bulgaria	42	42	40	39	40	0.77	0.91	0.71	0.83	0.80	0.80	0.80	0.80
Malaysia	43	45	63	58	63	0.80	0.83	0.75	0.46	0.79	0.73	0.74	0.71
Russian_Federation	44	46	57	48	55	0.69	0.95	0.74	0.54	0.79	0.74	0.75	0.74
Macedonia_TFYR	45	44	35	36	36	0.81	0.87	0.70	0.91	0.79	0.82	0.81	0.82

Panama	46	43	73	67	79	0.83	0.86	0.69	0.31	0.79	0.70	0.71	0.68
Belarus	47	47	39	40	39	0.75	0.95	0.67	0.86	0.79	0.80	0.80	0.81
Albania	48	48	38	38	38	0.81	0.89	0.65	0.91	0.78	0.81	0.80	0.81
Bosnia_and_Herzegovi	49	49	37	37	37	0.82	0.84	0.68	0.95	0.78	0.82	0.81	0.82
Venezuela	50	50	64	65	66	0.81	0.86	0.67	0.47	0.78	0.72	0.73	0.71
Romania	51	51	42	41	42	0.76	0.88	0.70	0.87	0.78	0.80	0.79	0.80
Ukraine	52	53	41	42	41	0.74	0.94	0.65	0.89	0.78	0.80	0.79	0.80
Saint_Lucia	53	52	54	51	57	0.79	0.88	0.66	0.60	0.78	0.74	0.75	0.73
Brazil	54	54	81	78	81	0.72	0.88	0.73	0.25	0.77	0.67	0.69	0.65
Colombia	55	55	80	77	80	0.78	0.84	0.69	0.29	0.77	0.67	0.69	0.66
Thailand	56	56	58	57	59	0.74	0.86	0.71	0.59	0.77	0.73	0.74	0.73
Kazakhstan	57	57	44	46	43	0.69	0.93	0.68	0.84	0.76	0.78	0.78	0.78
Jamaica	58	58	49	50	51	0.84	0.83	0.61	0.70	0.76	0.75	0.75	0.74
Armenia	59	59	52	54	54	0.79	0.90	0.57	0.70	0.75	0.75	0.74	0.74
Philippines	60	60	67	66	68	0.75	0.89	0.62	0.53	0.75	0.71	0.71	0.70
Turkmenistan	61	61	62	61	60	0.70	0.93	0.63	0.64	0.75	0.73	0.73	0.73
Paraguay	62	62	82	81	85	0.76	0.85	0.64	0.30	0.75	0.66	0.67	0.64
Peru	63	64	78	74	78	0.74	0.86	0.65	0.45	0.75	0.69	0.70	0.68
Turkey	64	63	59	60	58	0.76	0.80	0.69	0.66	0.75	0.73	0.73	0.73
Azerbaijan	65	65	51	56	53	0.78	0.88	0.58	0.73	0.75	0.75	0.74	0.74
Jordan	66	66	53	53	50	0.76	0.86	0.62	0.74	0.75	0.75	0.74	0.74
Tunisia	67	67	61	62	61	0.79	0.74	0.70	0.66	0.75	0.73	0.73	0.72
China	68	68	69	69	69	0.76	0.83	0.64	0.56	0.74	0.71	0.71	0.70
Georgia	69	69	55	59	56	0.81	0.89	0.52	0.73	0.74	0.74	0.73	0.73
Dominican_Republic	70	71	76	73	76	0.70	0.82	0.70	0.50	0.74	0.69	0.70	0.68
Sri_Lanka	71	70	50	52	48	0.79	0.83	0.60	0.78	0.74	0.75	0.74	0.75
Ecuador	72	72	70	70	71	0.76	0.85	0.60	0.58	0.74	0.71	0.71	0.70
Iran_Islamic_Rep_of	73	73	71	71	70	0.75	0.74	0.70	0.60	0.73	0.70	0.71	0.70
El_Salvador	74	74	83	83	87	0.76	0.75	0.65	0.38	0.72	0.65	0.66	0.64
Guyana	75	75	77	75	75	0.64	0.89	0.63	0.59	0.72	0.69	0.70	0.69
Uzbekistan	76	76	48	55	46	0.74	0.91	0.47	0.94	0.71	0.76	0.74	0.76
Algeria	77	77	65	68	62	0.74	0.69	0.68	0.76	0.70	0.72	0.71	0.72
Kyrgyzstan	78	78	56	64	52	0.72	0.92	0.46	0.89	0.70	0.74	0.73	0.74
Indonesia	79	80	68	72	65	0.69	0.80	0.58	0.78	0.69	0.71	0.70	0.71
Viet_Nam	80	79	72	76	67	0.73	0.82	0.52	0.74	0.69	0.70	0.70	0.70
Moldova_Rep_of	81	81	74	79	73	0.73	0.87	0.45	0.74	0.69	0.70	0.69	0.69
Bolivia	82	82	84	84	82	0.64	0.86	0.53	0.56	0.68	0.65	0.66	0.65
Honduras	83	84	91	90	90	0.73	0.74	0.54	0.34	0.67	0.61	0.61	0.59
Tajikistan	84	85	75	80	74	0.73	0.90	0.38	0.77	0.67	0.69	0.68	0.69
Nicaragua	85	83	90	91	91	0.74	0.73	0.54	0.34	0.67	0.61	0.61	0.59
Mongolia	86	86	85	85	84	0.64	0.89	0.47	0.57	0.67	0.65	0.65	0.64
South_Africa	87	88	94	92	95	0.40	0.83	0.77	0.25	0.66	0.57	0.60	0.57
Egypt	88	87	79	82	77	0.73	0.62	0.61	0.78	0.66	0.68	0.67	0.68
Guatemala	89	89	89	88	89	0.68	0.65	0.62	0.48	0.65	0.62	0.62	0.61
Morocco	90	90	87	87	88	0.72	0.53	0.61	0.67	0.62	0.64	0.63	0.63
Namibia	91	91	108	103	111	0.34	0.79	0.69	0.00	0.60	0.47	0.51	0.47
India	92	92	86	86	83	0.64	0.59	0.55	0.82	0.60	0.64	0.63	0.65
Botswana	93	93	105	100	105	0.27	0.76	0.73	0.17	0.57	0.49	0.52	0.50
Ghana	94	94	88	89	86	0.55	0.65	0.51	0.87	0.57	0.63	0.62	0.64
Cambodia	95	95	92	93	92	0.54	0.66	0.50	0.65	0.57	0.58	0.58	0.59
Papua_New_Guinea	96	96	99	99	101	0.54	0.57	0.52	0.43	0.54	0.52	0.52	0.52
Lao_People's_Dem_Rep	97	97	95	94	94	0.49	0.64	0.47	0.72	0.53	0.57	0.56	0.58
Swaziland	98	100	113	107	113	0.18	0.74	0.64	0.21	0.51	0.44	0.47	0.45
Bangladesh	99	98	93	95	93	0.60	0.45	0.47	0.83	0.51	0.58	0.56	0.58

Nepal	100	99	97	97	97	0.58	0.50	0.44	0.73	0.51	0.55	0.54	0.56
Cameroon	101	102	102	102	100	0.36	0.64	0.50	0.56	0.49	0.51	0.51	0.52
Pakistan	102	101	96	96	96	0.60	0.40	0.49	0.81	0.50	0.56	0.55	0.57
Lesotho	103	106	117	114	118	0.19	0.76	0.53	0.17	0.48	0.41	0.44	0.42
Uganda	104	103	101	101	99	0.34	0.70	0.44	0.60	0.49	0.51	0.51	0.52
Zimbabwe	105	107	114	111	114	0.15	0.79	0.53	0.30	0.48	0.44	0.46	0.45
Kenya	106	104	104	104	103	0.34	0.74	0.39	0.56	0.48	0.50	0.50	0.51
Yemen	107	105	98	98	98	0.58	0.50	0.36	0.80	0.48	0.55	0.53	0.55
Madagascar	108	108	107	108	110	0.47	0.60	0.33	0.50	0.47	0.47	0.47	0.47
Nigeria	109	110	112	112	112	0.44	0.59	0.36	0.43	0.46	0.46	0.46	0.46
Mauritania	110	109	100	105	102	0.45	0.42	0.52	0.68	0.46	0.51	0.50	0.52
Gambia	111	111	103	106	104	0.48	0.40	0.47	0.70	0.45	0.50	0.49	0.51
Senegal	112	112	106	109	106	0.46	0.39	0.46	0.63	0.44	0.48	0.47	0.48
Guinea	113	113	109	110	107	0.40	0.37	0.51	0.65	0.43	0.47	0.46	0.48
Tanzania_U_Rep_of	114	114	110	113	109	0.31	0.62	0.29	0.70	0.40	0.46	0.45	0.48
Cote_d_Ivoire	115	115	116	116	116	0.27	0.47	0.45	0.55	0.39	0.42	0.42	0.44
Zambia	116	116	121	120	120	0.13	0.68	0.36	0.39	0.38	0.38	0.39	0.39
Malawi	117	117	119	119	119	0.21	0.66	0.29	0.44	0.38	0.39	0.39	0.40
Central_African_Rep	118	118	124	123	124	0.25	0.43	0.41	0.21	0.36	0.33	0.34	0.33
Ethiopia	119	119	111	115	108	0.34	0.39	0.34	0.87	0.36	0.46	0.44	0.48
Mozambique	120	121	118	118	117	0.22	0.45	0.39	0.67	0.35	0.41	0.41	0.43
Guinea-Bissau	121	120	120	121	121	0.34	0.39	0.33	0.51	0.35	0.38	0.38	0.39
Burundi	122	122	115	117	115	0.26	0.45	0.31	0.80	0.34	0.43	0.42	0.45
Mali	123	123	122	122	122	0.39	0.21	0.37	0.44	0.33	0.35	0.34	0.35
Burkina_Faso	124	124	123	124	123	0.35	0.16	0.40	0.49	0.31	0.34	0.34	0.35
Niger	125	125	125	125	125	0.35	0.18	0.35	0.44	0.30	0.32	0.32	0.33
Source: Sarker et al. (adapted from HDRs of UNDP); PCI is named as GDP in HDR/Sarker et al.											Computed by us		



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DEPARTMENT OF ECONOMICS
NORTH-EASTERN HILL UNIVERSITY, SHILLONG (INDIA)
CONTACT: mishrasknehu@yahoo.com