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Sustainable Development as a Single Measure: Case Study of Some Developing Asian Countries

Zrównoważony rozwój jako kompleksowe narzędzie pomiarowe: Przykład wybranych azjatyckich krajów rozwijających

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Abstract
The Rio Earth Summit of 1992 had emphasized on the development of suitable indicators for the measurement of sustainable development, as aids for decision-making at all levels. In this paper, the authors demonstrate how a Holistic National Sustainability Index can be constructed, by taking into consideration four dimensions of sustainability – Social, Economic, Environmental and Infrastructural. The methodology is applied to 12 developing Asian countries, where sustainable development is vital in the years to come. Comparison among countries using their respective Indices would be meaningless; it is not the *states* the countries are at a given point in time, but the *paths* which they follow over time, on the sustainability curve, which are comparable. Limitations and subjectivity notwithstanding, such an Index when used on its merit (with complete understanding of its deficiencies), can be a good planning tool for decision-makers at all levels of government.
Keywords: sustainability, economic, environmental, social, infrastructural, low-income, lower middle income, upper middle income, trade, agriculture, services, export-import ratio, life-expectancy

Streszczenie
Podczas Szczytu Ziemi w Rio w 1992 podkreślono konieczność sformułowania wskaźników rozwoju zrównoważonego, które stanowiłyby istotną pomoc dla decydentów na wszystkich szczeblach.
W niniejszym artykule, autorzy pokazują, jak skonstruować Holistyczny Krajowy Indeks Zrównoważoności, uwzględniając cztery filary zrównoważonego rozwoju – społeczny, ekonomiczny, ochronę środowiska i infrastrukturę. Badania odnoszą się do 12 azjatyckich krajów rozwijających, gdzie możliwość wprowadzenia rozwoju zrównoważonego będzie w nadchodzących latach kluczowym zagadnieniem. Porównanie krajów stosujących swoje własne indeksy nie miałoby sensu, nie chodzi tu o *stany*, w których kraje się znajdują w danym momencie, ale o *ścieżki*, którymi podążają w kierunku zrównoważoności.
Mimo ograniczeń i pewnej subiektywności, taki Indeks (z uwzględnieniem jego braków), może być dobrym narzędziem planowania dla decydentów na wszystkich poziomach zarządzania.

Słowa kluczowe: zrównoważoność, ekonomia, środowisko, społeczeństwo, infrastruktura, dochód, handel, rolnictwo, usługi, relacja eksport-import, oczekiwana długość życia

1. Introduction

Sustainability is a condition or a state, while sustainable development is a process or a set of strategies which when implemented, is supposed to take one towards that state. Being a moving target, sustainability needs to be pursued anew every time the factors influencing it keep changing. European Communities (2007) is one of the many publications in which this distinction is brought out clearly. As Kallio, et al. (2007) has said, the phenomenon we label as sustainable development can never be exhaust-

ively defined; it would constantly change with time, interpreters and their needs. We thus have an elusive, impermanent end-goal, which is pursued with a changeable set of ways and means. Quental, et al. (2011) has stated that the introduction of sustainable development as a concept was an intellectual answer to reconcile the conflicting goals of environmental protection and economic growth. Pawlowski (2008) emphasizes on the fact that technology alone cannot solve the problems which the world encounters in the 21st century. The social and economic aspects of sustainable development need to be factored in.

Ehrenfeld (2009) has said that when one talks about sustainability, one is usually expressing a desire to maintain some emergent property over long periods of time. The paper refers to it as a *meta-quality*. Guha (1992, p. 60) has talked about *orderly growth; not growth at the expense of order or for that matter, order at the expense of growth*. The abstractness associated with it can be concretised to some extent by identifying and defining certain indicators – by following the processes of conceptualisation and operationalisation commonly used in the social sciences (Singhirunnusorn and Stenstrom, 2009). An indicator, as an OECD report defined it (Keirstead and Leach, 2008), is a parameter or a value derived from parameters, which points to, provides information about, and describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with the parameter value.

To understand the status quo that prevails at the time of writing, one would need to relate it to the past for what obtains now is the sum total of all that has been and occurred in the past. It is here that a time-series analysis – a peep into history so to say – becomes important. Having seen and understood the present with respect to the past, the future course of action (course corrections in other words) can be planned. As Cameron and Neal (2003) believe, *a correct diagnosis of the origins of a problem does not in itself guarantee an effective prescription but without such a diagnosis one can scarcely hope to remedy the problem.* Singhirunnusorn and Stenstrom (2009) have defined seven principles at the top of the hierarchy. Sustainability – considered as an environmental aspect – is one of them. On the second rung are criteria and on the last, measurable indicators.

In 2009, the Economist Intelligence Unit (London, UK), sponsored by Siemens (Germany), published the European Green City Index report (Economist Intelligence Unit, London 2009). A total of 30 cities (most of them capital cities of European countries) were studied under eight different categories: Carbon dioxide; Energy; Transport; Water; Environmental Governance; Waste and land use; Air quality; and Buildings. In total, these eight categories were composed of 30 indicators. As Venkatesh (2012) advocates, a blind pursuit of a higher Green City Index is certainly not to be recommended, but rather an integration of the Green City Index with a Socio-Economic Index. City authorities could use the knowledge of the inter-linkages and correlations among the different indicators (and Indices) to chart the course ahead, while ensuring that complementarities and synergies are fully harnessed. In Venkatesh and Brattebø (2012), the authors have recommended the classification of cities into city types based on specific attributes and identification of relevant environmental sustainability indicators – for urban water and wastewater systems in particular – from a pool of 13 indicators, for these different city types.

There is the Multi-dimensional Poverty Index (MPI) developed by Sabina Alkire and her colleagues at the Oxford Poverty and Human Development Initiative (The Economist, 2013A, p. 71). MPI considers poverty to be three-dimensional – Health, Education and Living Standards equally-weighted – and defines ten indicators in all. The Index's defenders point out that the weighting factors may be arbitrary, but at least they are explicit. Otherwise, priorities are set implicitly, and sometimes inadvertently, by the push and pull of politics. Combining these dimensions into a single score by which countries can be compared, also concentrates minds. Alkire says that when the MPI is adopted, countries like Uganda and Rwanda seem to show marked development as far as reduction of multi-dimensional poverty is concerned; while the simplistic USD 1.25 per day measure paints them in a relatively poorer light.

Five indicators – maternal health, children's well-being, educational status (of mothers), economic status (of mothers) and political status (of mothers) – are aggregated together by the NGO Save the Children in State of the World's Mothers – 2013 (Save the Children, 2013), to arrive at a Mother's Index for 176 countries of the world. The United Nations Development Programme has its Inequality-adjusted Human Development Index (UNDP), which takes into account Income, Life-Expectancy and Education.

The World Bank also developed the Logistics Performance Index (LPI) in 2010, with the criteria being Customs, Infrastructure, International shipping, Logistics, Tracking & Tracing and Timeliness. Among Asian countries, Singapore and Japan figured in the top 10, with scores of 4.09 and 3.86, out of a maximum of 5. China's LPI was 7th in Asia and 27th in the world, while Malaysia was 8th and 29th respectively (Venkatesh, 2011). Talking of infrastructure and the role it plays in sustainable development, it is apt to mention at this juncture that the value of the infrastructure stock in China and India, in year-2012, was 75% and 58% of their respective GDPs in the said year (the average of big economies is around 71%, The Economist, 2013B).

In this paper, the authors demonstrate how a Total (National) Sustainability Index (TSI) can be con-

structed, by taking into consideration four dimensions of sustainability – Social, Economic, Environmental and Infrastructural. The methodology is applied to (tested on) 12 developing Asian countries, where sustainable development is vital in the years to come. The total population of these countries (which include China, India and Indonesia) accounts for nearly 50% of the total global population. These countries have been categorised into three groups – Low Income (3 – Nepal, Cambodia and Bangladesh), Lower-Middle Income (6 – India, Sri Lanka, The Philippines, Vietnam, Indonesia and Bhutan) and Upper-Middle Income (3 – China, Malaysia and Thailand), based on the classification scheme adopted by the World Bank (also refer Appendix I). It should also be noted at this juncture that comparison among countries using their respective Indices would be meaningless; it is not the *states* the countries are at a given point in time, but the *paths* which they follow over time, on the sustainability curve, which are comparable.

2. Methodology

It is in keeping with the need for an integrated approach referred to in the previous section, that this paper takes a holistic approach to defining sustainability and calculating a Total Sustainability Index (TSI). Infrastructure development is the key to social welfare and economic growth. It may have both positive and negative impacts on the environment. Investments in infrastructure development are primarily policy-decisions at the level of national and provincial governments. It thus follows that good governance and effective policymaking are *sine qua non* for sustainable development. The four dimensions considered for the purpose of this paper are Economic (E), Social (S), Environmental (EN) and Infrastructural (I). The indicators selected under each of these, are numbered as E1, S1, EN1, I1 and so on. In order to differentiate among the values of the same indicator for different years, the year is added on as a subscript to the notation. For the reference year, the values of all the indicators equal 1 (actual value in baseline year divided by itself). The values of the suitably-subscripted indicators for the years following the reference year are obtained by dividing the actual value for the year under consideration by the value in the reference year. Table 1 lists the 18 selected indicators under the four dimensions considered, with their notations, and also categorises them on the basis of whether an increase in the normalised indicator value is desirable for sustainability or not. Primary, secondary and tertiary sectors, in addition to trade-balance are accounted for under the economic dimension. Household consumption, literacy, access to water and sanitation facilities, life-expectancy at birth (males and females) are considered under the social dimension to encompass health, education, and well-being. Quite contrary to the usual hackneyed focus on GHG emissions when it comes to environmental performance, the canvas is spread out a little wider to include water (fertiliser consumption which influences eutrophication of water bodies, serving as a proxy), atmosphere (GHG emissions), flora and fauna (terrestrial and marine protected areas) and renewable content of the electricity mix (which has far-reaching effects on land, water, soil in general). As far as infrastructure is concerned, electricity generation (which influences economic development and social welfare; while possibly having a negative impact on the environment depending on the sources availed of), transport and communication (motorable roads and telecommunication facilities, which are extremely vital in present-day Asia to connect seller to buyer, labour to worksites, supply to demand) are taken into account. The authors are of the contention that this selection of 18 indicators lends, by and large, a degree of holism to the definition of *sustainable development*.

Table 1. Listing and categorisation of the indicators selected

Increase in normalised indicator value desirable	
Notation	
E1	Economic value added by primary sector (agriculture, fishing, forestry etc.)
E2	Economic value added by secondary sector (manufacturing etc.)
E3	Economic value added by tertiary sector (services)
E4	Export-import ratio
I1	Electricity generation per capita
I2	Percentage of paved roads
I3	Mobile cellular subscriptions per 100 people
I4	Telephone lines per 100 people
EN2	Percentage of renewable content in electricity mix
EN4	Percentage of terrestrial and marine protected areas
S1	Household final consumption per capita
S2	Adult literacy rate
S3	Percentage of population with access to improved water source
S4	Percentage of population with access to sanitation facilities
S5	Life expectancy at birth (female)
S6	Life expectancy at birth (male)
Decrease in normalised indicator value desirable	
Notation	
EN1	Specific fertiliser consumption (per hectare of arable land)
EN3	Carbon dioxide emissions per capita

Quite obviously, an increase in the value of an indicator like GHG emissions per capita, is unsustainable, while an increase in the literacy rate is very much desirable for sustainable development (refer Appendix II). The data were sourced from the website of the World Bank in March 2013, by accessing each individual country page and downloading the Excel file with the time series of data for a long list

of indicators. The time period to which the authors restricted themselves was 2003 to 2010. For some countries, owing to non-availability of comprehensive data, the time period was contracted a little to 2003-2009. Gaps in the data streams were filled up by resorting to other sources/contacts – *index mundi.com,* for instance. Some simple assumptions had to be made. For instance, if the data for the percentage of paved roads is available for year-2004 and year-2008, and there are gaps for the 3 years in between, a linear change is assumed from the 2004-2008 period (increase or decrease as the case may be). Also, for example, if data are not available for the last 2 years of the time period, years 2009 and 2010, then the value for year 2008 is assumed to hold for these years. Likewise, in cases of non-availability of data for say years 2003, 2004 and 2005, the value for year-2006 is assumed to hold for them. Data for the adult literacy rate (% of population above the age of 15) are quite scarce. In cases where there are no responses to data-requests made to government agencies in the respective countries, a similar approach as described above is adopted. This, no doubt, reduces the accuracy of the final results gleaned from the analysis. The assumptions are resorted to, for want of a better way to confront these data gaps. However, this approach is adopted for only those indicators which are measured as percentages.

The author despatched an e-mail questionnaire to researchers and other professionals originating from some of the countries analysed, in October 2013. The purpose was to collect opinions from the respondents about the weighting factors – intra-dimensional and inter-dimensional. Policymakers in the Asian governments, needless to mention, were not accessible to the authors. Policymakers in democracies are elected by the people – directly or indirectly. However, it is not always so, that they represent the will or opinions of the electorate faithfully. Hence, this exercise of reaching out to educated people to collect sets of weighting factors is tantamount to a *direct-democracy* approach, through which decisions can be made and policies formulated on the basis of the knowledge of what the people opine. In order to render more meaning to the rationale of this approach, it would ideally be necessary to reach out to vast swathes of the populations of the countries studied. That, needless to say, is difficult. Besides, the possibility that some or most of the requests sent (by e-mail) will go unanswered also has to be accepted. All the respondents have spent 20 years or more in their country of origin and thereby have the credentials to opine about the relative weighting of the different indicators, keeping the state of affairs in their respective countries in mind. **Appendix III** lists the names, nationalities, ages and years-resident-in-country-of-origin of the respondents. Some admitted that it was very difficult to assign the weightages, thus reflecting the inevitable difficulty which policymakers find themselves in, if asked to do so.

For the purpose of this paper, one response per group (Low Income, Low-middle income and Upper-middle income) is deemed to be sufficient. If multiple responses are received, per group, averages are considered (the respondents have been acknowledged at the end of the paper). Often, one debates and discusses the relevance of one set of weighting factors prescribed for one particular country, to another one. But it is often widely believed that an aggregation of the weighted scores is a more convenient way of comparing and contrasting, when decisions need to be based on a very wide range of criteria.

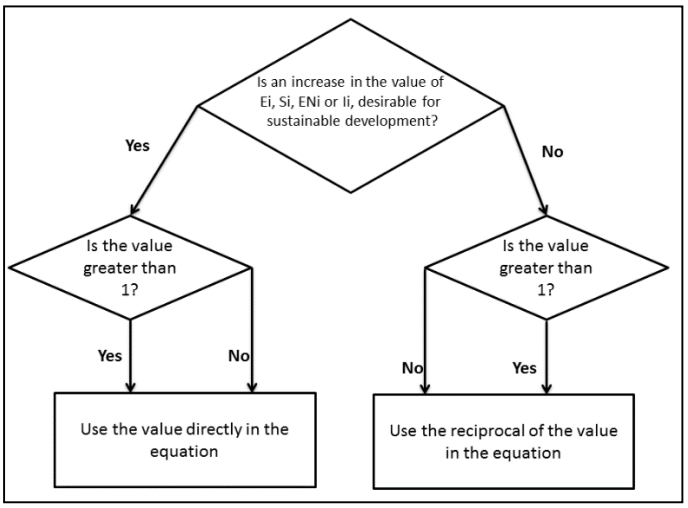

Figure 1. Flowchart to explain the choice between the quotient or its reciprocal in Eq 1

Equation 1 adopts weighted arithmetic averaging of the normalized indicators within each dimension, followed by weighted arithmetic averaging again of the component indices of the total sustainability index (abbreviated as TSI earlier). It must be mentioned at this juncture that whether to use the normalized indicator (Ei, Si, ENi or Ii) or its reciprocal (1/Ei, 1/Si, 1/ENi or 1/Ii) in the summation is to be decided with reference to Table 1 and the flowchart in Figure 2.

$$TSI = W_{\mathrm{E}} \sum_{i=1}^{n} w_{\mathrm{Ei}} * Ei \left(or \frac{1}{Ei}\right) + W_{\mathrm{S}} \sum_{\substack{i=1 \\ j}}^{m} w_{\mathrm{Si}} * Si \left(or \frac{1}{Si}\right) + W_{\mathrm{EN}} \sum_{\substack{i=1 \\ k}}^{} w_{\mathrm{ENi}} * ENi \left(or \frac{1}{ENi}\right) + W_{\mathrm{I}} \sum_{i=1} w_{\mathrm{Ii}} * Ii \, (or \frac{1}{Ii})$$

- *Equation 1.*

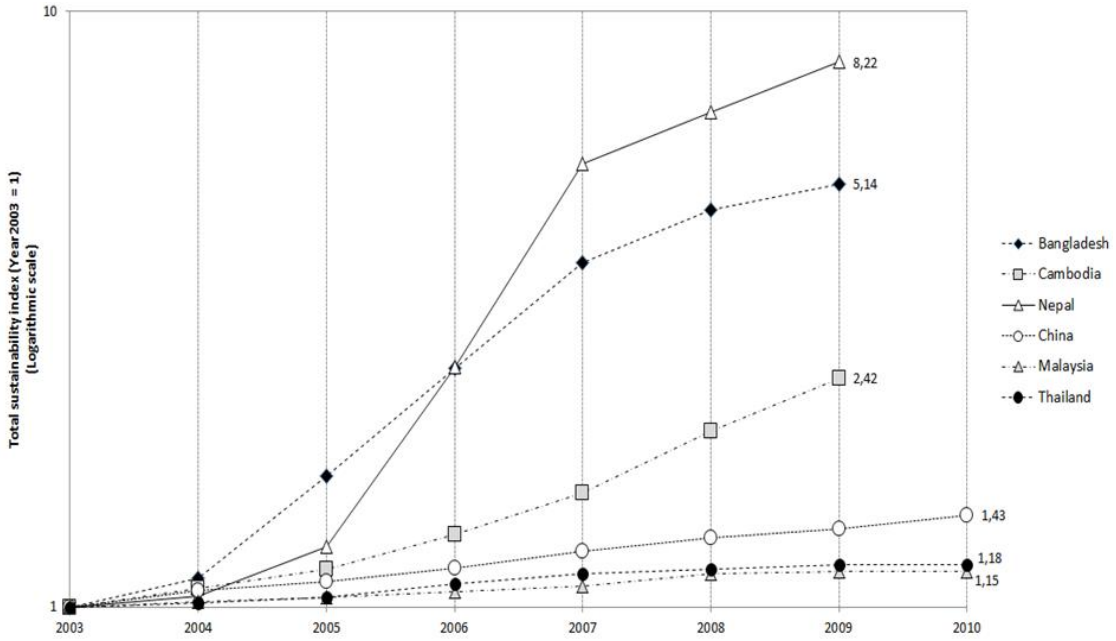

Figure 2. TSI for the Low Income and High-Middle Income countries considered in this study (with respect to year-2003, for each country)

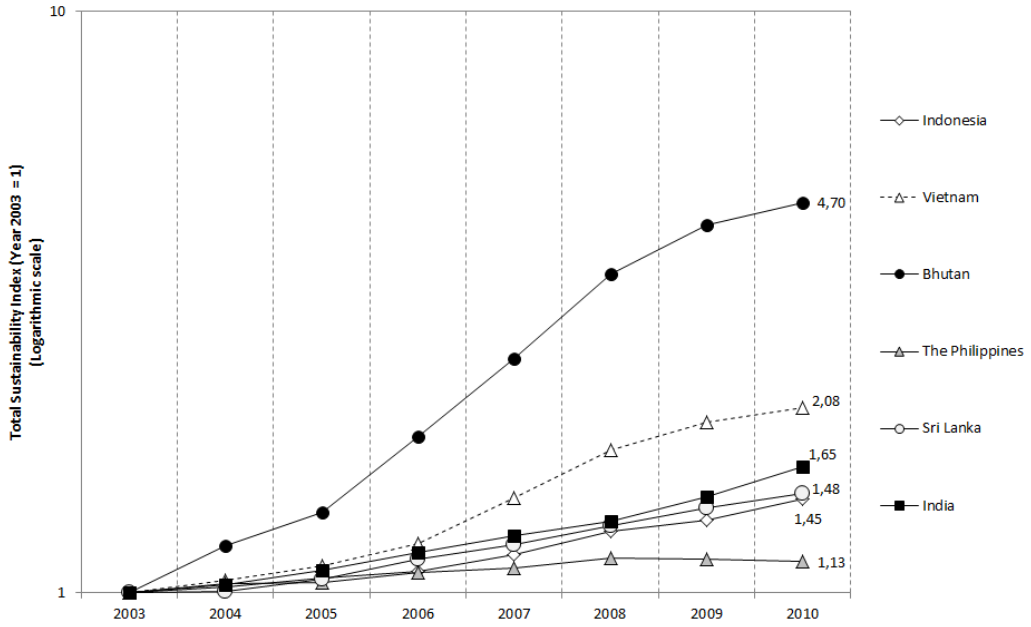

Figure 3. TSI for the Low-Middle Income countries considered in this study (with respect to year-2003, for each country)

In Equation 1, TSI is the Total Sustainability Index for a given year. W_E, W_S, W_{EN} and W_I are the weighting factors for the four component indices – economic, social, environmental and infrastructure respectively, such that the sum of these four equals 1. The notations *n*, *m*, *j* and *k* (the limits of the four summations), stand for the numbers of indicators within the Economic, Social, Environmental and Infrastructural dimensions respectively. Ei, Si, ENi and Ii, as mentioned above are the normalized i^{th} indicator values for the given year. The weighting factors for these indicator values are w_{Ei}, w_{Si}, w_{ENi} and w_{Ii} respectively, such that the weighting factors in each of the four dimensions (*n*, *m*, *j* and *k* in number) sum up to 1.

As the concept of a total sustainability index (TSI) is relatively new, there is scope in this paper to suggest the use of a geometric weighted averaging approach instead of an arithmetic weighted averaging one. In fact, one could adopt a hybrid averaging approach. The individual indices for the criteria can be obtained by geometric/arithmetic averaging and the final holistic sustainability index may be calculated thereafter by arithmetic/geometric averaging. How-

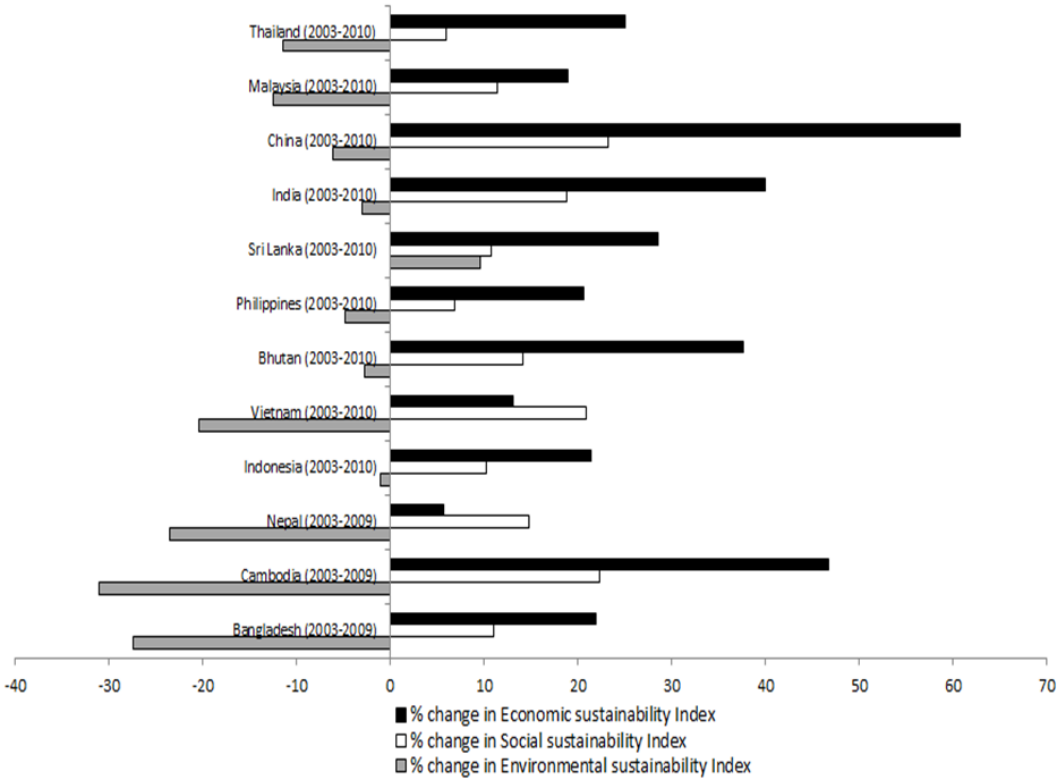

Figure 4. Changes in the sustainability indices for three of the four criteria, for all the 12 countries, over the specified time period for each of them

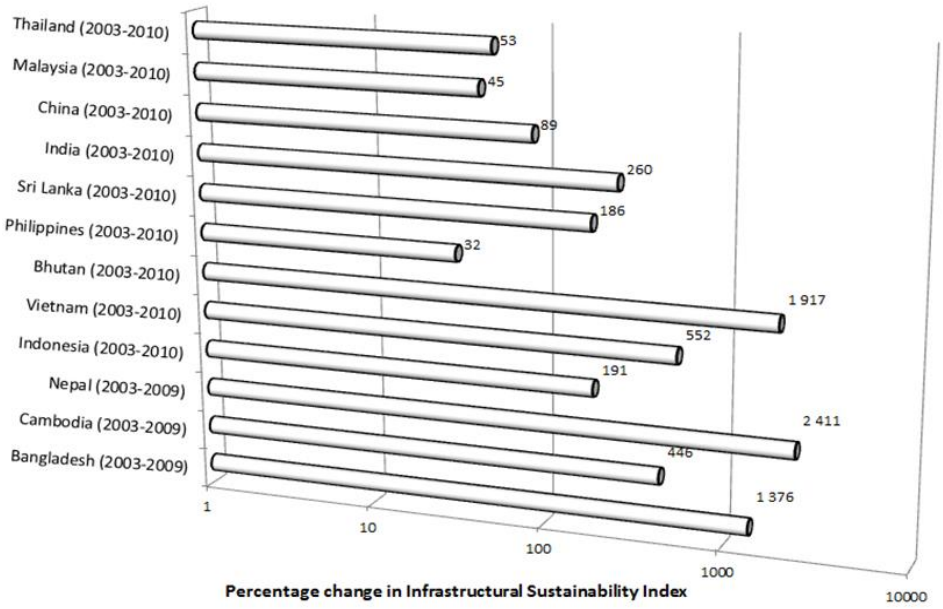

Figure 5. Changes in the Infrastructural Sustainability Index for all the 12 countries, over the specified time period for each of them

ever, the authors would like to leave these at this juncture as suggestions and not venture into calculating the TSI using these three alternate methods.

3. Results and discussion

Tables 2, 3 and 4 tabulate the weighting factors received in response to e-mails sent, for each of the three groups of countries. The average and standard deviation of the factors have also been included. The average is used for the calculation of the TSI. The respondents' ages fall in the range of 25-45 (average being close to 33). They are representative of the generation which will strongly influence (and be influenced by) changes happening in the world in the next two decades. Their prioritisation thereby can be considered to be quite realistic for the near future.

Table 2. Weighting factors for Low Income countries

Weighting factor	Values from responses (in %), separated by commas
W_E	25
W_{EN}	25
W_S	20
W_I	30
w_{E1}	60
w_{E2}	20
w_{E3}	10
w_{E4}	10
w_{S1}	20
w_{S2}	25
w_{S3}	15
w_{S4}	20
w_{S5}	10
w_{S6}	10
w_{I1}	10
w_{I2}	30
w_{I3}	40
w_{I4}	20
w_{EN1}	30
w_{EN2}	30
w_{EN3}	20
w_{EN4}	20

On average, for the Low-Middle Income group of countries (for which there were many responses), respondents value the socio-economic over the environmental and infrastructural. The primary sector gets a greater weighting vis-à-vis the secondary, tertiary and the trade balance; the last three being weighted almost equal to each other. Renewable energy (as percentage of total electricity generation), the percentage of paved roads and the per-capita total electricity generation itself are more important indicators. Access to water supply, quite obviously, gets 3 percentage points more than access to sanitation; for the latter ideally ought to follow the former. For the High-Middle Income group (all respondents were incidentally of Chinese provenance), the environment is weighted over the social, economic and infrastructural. Within the environmental sustainability criterion, the *percentage of terrestrial and marine protected areas* is weighted the highest. The export/import ratio and the growth in the tertiary sector are prioritised over the growth in the primary and secondary sector, within the economic sustainability criterion.

Table 3. Weighting factors for Low-Middle Income countries

Weighting factor	Values from responses (in %), separated by commas	Average	Standard deviation
W_E	60, 20, 30, 20, 40, 30, 25, 25, 25, 20	29.5	12.3
W_{EN}	5, 20, 30, 40, 10, 20, 25, 15, 20, 30	21.5	10.3
W_S	30, 40, 30, 10, 40, 35, 25, 35, 35, 25	30.5	8.9
W_I	5, 20, 10, 30, 10, 15, 25, 25, 20, 25,	18.5	8.1
w_{E1}	25, 50, 20, 20, 20, 50, 40, 30, 25, 25	30.5	11.8
w_{E2}	25, 15, 30, 20, 20, 30, 20, 25, 30, 30	23.5	5.3
w_{E3}	25, 15, 30, 30, 40, 10, 20, 15, 20, 20	23.5	9.1
w_{E4}	25, 20, 20, 30, 20, 10, 20, 30, 25, 25	22.5	5.9
w_{S1}	20, 20, 20, 10, 45, 20, 60, 10, 20, 10	23.5	16.3
w_{S2}	15, 25, 20, 20, 5, 10, 5, 10, 15, 25	15	7.45
w_{S3}	20, 5, 20, 30, 20, 20, 20, 20, 25, 15	20	7.1
w_{S4}	15, 5, 20, 30, 20, 20, 5, 20, 20, 20	17	7.5
w_{S5}	15, 15, 10, 10,5, 15, 5, 20, 10, 15	12	4.8
w_{S6}	15, 20, 10, 10, 5, 15, 5, 20, 10, 15	12.5	5.4
w_{I1}	25, 30, 50, 20, 40, 40, 60, 35, 30, 30	36	9
w_{I2}	25, 50, 30, 40, 40, 25, 20, 30, 60, 40	36	12.9
w_{I3}	25, 10, 10, 20, 10, 15, 5, 15, 5, 10	13	5.8
w_{I4}	25, 10, 10, 20, 10, 20, 5, 20, 5, 20	15	6.6
w_{EN1}	25, 20, 0, 30, 10, 20, 30, 25, 15, 15	19	9.3
w_{EN2}	25, 20, 50, 40, 40, 40, 50, 30, 40, 40	37.5	9.7
w_{EN3}	25, 10, 20, 15, 40, 25, 10, 15, 30, 5	19.5	10.6
w_{EN4}	25, 50, 30, 15, 10, 15, 10, 30, 15, 40	24	13.4

Table 4. Weighting factors for High-Middle Income countries

Weighting factor	Values from responses (in %), separated by commas	Average	Standard deviation
W_E	30, 20, 20, 30	25	5.8
W_{EN}	20, 30, 40, 30	30	8.2
W_S	20, 15, 20, 20	18.75	2.5
W_I	30, 35, 20, 20	26.25	7.5
w_{E1}	25, 30, 20, 10	21.25	8.5
w_{E2}	25, 15, 30, 20	22.50	6.4
w_{E3}	25, 15, 30, 40	27.50	10.4
w_{E4}	25, 40, 20, 30	28.75	8.5
w_{S1}	20, 25, 10, 25	20	7.1
w_{S2}	10, 20, 20, 20	17.50	5
w_{S3}	20, 10, 35, 10	18.75	11.8
w_{S4}	20, 20, 15, 25	20	4.1
w_{S5}	15, 15, 10, 10	12.50	2.5
w_{S6}	15, 10, 10, 10	11.25	2.9
w_{I1}	30, 40, 30, 30	32.50	5
w_{I2}	30, 10, 40, 40	30	14.1
w_{I3}	20, 25, 20, 15	20	4.1
w_{I4}	20, 25, 10, 15	17.50	6.4
w_{EN1}	30, 15, 20, 20	22.25	6.3
w_{EN2}	25, 35, 20, 40	30	9.1
w_{EN3}	20, 10, 10, 20	15	5.7
w_{EN4}	25, 40, 50, 20	33.75	13.7

Figure 2 and Figure 3 depict the trends in the TSI for each of the twelve countries. For each country, the values for years 2004 and later, are normalised with respect to the state of each country in year-2003. As mentioned before in the paper, care should be exercised in interpreting the graphs. They are not intended for comparing the states of different countries at any point in time; but rather the relative sustainability performance over time, with respect to year-2003 . The TSI of Nepal increased by 822% over the seven-year period 2003-2009. During the same period, Cambodia and Bangladesh registered increases of 242% and 514% respectively. These increases were largely courtesy the rapid rise in the value of the infrastructural indicator – Mobile subscriptions per 100 people – over the said period (refer Figure 5). The high-middle income countries registered modest increases in TSI of 43% (China; at a CAGR of close to 5%), 18% (Thailand; at a CAGR of 2.4%) and 15% (Malaysia; at a CAGR of 1.9%). Among the Low-middle income countries, Bhutan's TSI grew fastest and stood at 4.7 in 2010 (with respect to 1 in year-2003). The others recorded increases in the range of 13% to 108%. It must be pointed out at this juncture that the TSI for the Philippines rose from year-2003 and peaked in year-2008 before dropping down slightly to its relative value of 1.13 in 2010.

Figure 4 depicts the changes in the social, economic and environmental indices for the 12 countries, while Figure 5 does the same for the infrastructural. Among the Low Income countries, over the period 2003-2009, the changes in the Economic, Environmental and Social Sustainability Indices were the greatest for Cambodia at 46.6%, -31% and 22.4% respectively; while Nepal registered the highest increase in the Infrastructural Sustainability Index (2411%). Bangladesh. Nepal and Cambodia – countries in the lower stratum of the developing world, register relatively faster increases in their respective TSIs vis-à-vis those in the Low Middle Income and High-Middle Income groups. This is courtesy the harnessing of the *low-hanging fruit* in this case – especially the rapid growth in the value of the indicator *mobile subscriptions per 100 people*. Of course, results obtained in this paper are sensitive to (and dependent on) the choice of indicators as well as the weighting factors.

As far as the Low-Middle Income countries are concerned, over the period 2003-2010, the corresponding countries and the percentages of increase were India (40%), Vietnam (-20.5%) Vietnam again (21%) and Bhutan (1917%). For the three High-Middle Income countries in the fray, over the time period 2003-2010, China was the leader of the pack in all categories expect one. While the Environmental Sustainability Index dropped for all three countries, Malaysia recorded the highest drop (-11.9%). Among all the 12 countries, it was only Sri Lanka whose Environmental Sustainability Index improved over the 8-year period, by 9.55%.

It is seen that a drop in the environmental sustainability index (or a relatively slow growth in the same), is a price to be paid to effect improvements in the other three indices. The environmental sustainability index, thus tends to retard the rise in the TSI. A growth in the Gross Domestic Product per-capita is most welcome, but what it more important is what it entails for social sustainability, and at what cost to the environment such growth happens.

4. Conclusions and recommendations

Ideally, different countries would adopt different sets of indicators. Weighting factors also may usually not be the same for different countries. They would also not be constant over time. Such factors are usually aligned closely with the realities-on-the-ground and policies formulated by governing bodies. Thus, it follows that they need to re-examined from time to time – both the indicators themselves and their weighting factors. Re-evaluation is necessary as some indicators may cease to be of importance after some time (and may have to be excluded or down-weighted). New challenges would then call for reformulation in the policies and thereby the definition of new indicators.

Weighting factors are subjective but as mentioned in the Literature Review section, *at least they are explicit. Otherwise, priorities are set implicitly, and sometimes inadvertently, by the push and pull of politics. Combining these dimensions into a single score by which countries can be compared, also concentrates minds.* The comparison referred to in the previous sentence is not one among the *states* of countries at any given period of time, but rather among the *paths* from the starting point on their respective curves of sustainable development. Comparing the *states* is meaningless as the starting points are not the same, and some countries are endowed with geographical and/or natural and/or historical advantages – more so than the others.

Some countries measure and record data systematically and make them available to the World Bank. Many do not. Further, apart from the data gaps, there is also some uncertainty as regards the accuracy of the data recorded (or measured and submitted to the recording authority – the World Bank in this case). As reported in The Economist (2013C, p 47), if activity in the informal sector and rural areas were properly measured in India, its GDP would look bigger and more stable. The new head of the Reserve Bank of India – Raghuram Rajan – is quoted in the same news item, as saying that the GDP could be revised by as much as 10%.

The applicability of this method is highly dependent on the availability of reliable, and reasonably-accurate data; also comprehensive to boot. Governments may be encouraged to invest more resources in data gathering in this era of *Big Data*, where robust decisions can be taken by crunching numbers using models like the one developed in this paper.

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Appendices

I. World Bank classification of the 19 Asian countries considered (July 2012)

Low income	Lower Middle income	Upper middle income
Bangladesh Cambodia Nepal	Bhutan Indonesia The Philippines Vietnam Sri Lanka India	China Malaysia Thailand

II. Explanations of the fields selected from the World Bank database, for direct use as indicators or as primary data for derived indicators

ECONOMIC

- ***Imports of goods and services (% of GDP)*:** Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in constant 2000 U.S. dollars.
- ***Trade (% of GDP):*** Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
- ***Agriculture, value added (% of GDP):*** Agriculture includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.
- ***Industry, value added (% of GDP):*** Industry corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.
- ***Services, value added (% of GDP):*** Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade

(including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling

- ***GDP (constant USD):*** GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.
- ***GDP per capita (constant USD):*** GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars.

SOCIAL

- ***Household final consumption expenditure, etc.:*** Household final consumption expenditure (formerly private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported separately by the country. This item also includes any statistical discrepancy in the use of resources relative to the supply of resources. Data are in constant 2005 U.S. dollars.
- ***Literacy rate, adult total:*** Adult (15+) literacy rate (%). Total is the percentage of the population age 15 and above who can, with understanding, read and write a short, simple statement on their everyday life. Generally, *literacy* also encompasses *numeracy*, the ability to make simple arithmetic calculations. This indicator is calculated by dividing the number of literates aged 15 years and over by the corresponding age group population and multiplying the result by 100.
- ***Improved water source (% population with access):*** Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 liters a person a day from a source within one kilometer of the dwelling.
- ***Improved sanitation facilities (% population with access):*** Access to improved sanitation facilities refers to the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection. To be effective, facilities must be correctly constructed and properly maintained.
- ***Life expectancy at birth (years):*** Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

ENVIRONMENTAL

- ***Fertiliser consumption (kg/hectare of arable land):*** Fertilizer consumption measures the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). Traditional nutrients – animal and plant manures – are not included. For the purpose of data dissemination, FAO has adopted the concept of a calendar year (January to December). Some countries compile fertilizer data on a calendar year basis, while others are on a split-year basis. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded.
- ***Electricity production from renewable sources (kWh):*** Electricity production from renewable sources includes hydropower, geothermal, solar, tides, wind, biomass, and biofuels.
- ***Carbon dioxide emissions (metric tons per capita):*** Carbon dioxide emissions are those

stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.

- ***Terrestrial and marine protected areas (% of total territorial area):*** Terrestrial protected areas are totally or partially protected areas of at least 1,000 hectares that are designated by national authorities as scientific reserves with limited public access, national parks, natural monuments, nature reserves or wildlife sanctuaries, protected landscapes, and areas managed mainly for sustainable use. Marine protected areas are areas of intertidal or sub-tidal terrain – and overlying water and associated flora and fauna and historical and cultural features – that have been reserved by law or other effective means to protect part or all of the enclosed environment. Sites protected under local or provincial law are excluded.

INFRASTRUCTURAL

- ***Electricity production (kWh):*** Electricity production is measured at the terminals of all alternator sets in a station. In addition to hydropower, coal, oil, gas, and nuclear power generation, it covers generation by geothermal, solar, wind, and tide and wave energy, as well as that from combustible renewables and waste. Production includes the output of electricity plants that are designed to produce electricity only as well as that of combined heat and power plants.
- ***Roads, paved (% of total roads):*** Paved roads are those surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones, as a percentage of all the country's roads, measured in length.
- ***Mobile cellular subscriptions (per 100 people):*** Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service using cellular technology, which provide access to the public switched telephone network. Post-paid and prepaid subscriptions are included.
- ***Telephone lines (per 100 people):*** Telephone lines are fixed telephone lines that connect a subscriber's terminal equipment to the public switched telephone network and that have a port on a telephone exchange. Integrated services digital network channels and fixed wireless subscribers are included.

III. Respondents who opined about weighting factors

Name	Age	Country of origin	Years resident in country of origin	Gender
Bertha Maya Sopha	36	Indonesia	25	Female
Bhawna Singh	32	India	24	Female
Chao Fu	30	China	25	Male
Citra Prasetyo	26	Indonesia	22	Female
G Venkatesh (author)	41	India	32	Male
Gang Liu	31	China	26	Male
Gema Sakti Raspati	36	Indonesia	28	Male
Juan Tan	30	China	25	Female
Kamna Sachdeva	34	India	34	Female
Netra Timalsina	35	Nepal	30	Male
Sunand Sreeramachandran	33	India	22	Male
Ushanth Navaratnam	29	Sri Lanka	26	Male
Vera Gunawan	40	Indonesia	25	Female
Xinxin Wang	31	China	26	Female
	Average age: **33**		Average: **26**	

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