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Original Article

The Human Sustainable Development Index: New calculations and a first critical analysis

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ABSTRACT

The *Human Sustainable Development Index* (HSDI) has been proposed as a way to amend the United Nations' *Human Development Index* (HDI) by adding an environmental dimension. Despite some attention in the media, the HSDI remained largely ignored by the scientific community. This paper aims at overcoming this issue by presenting an updated version of the index, based on recently available UN data, including a complete description of the procedure leading to its calculation and a critical assessment of its relation with some established environmental indicators. We found that, while the HSDI represents a step ahead from the HDI, it remains insufficient in its representation of environmental sustainability. A better equilibrium between social, economic and environmental goals is needed to reach a true index of sustainable development.

1. Introduction

The *Human Sustainable Development Index* (HSDI) has been proposed as a way to amend the "iconic" United Nations' *Human Development Index* (HDI) by adding an environmental dimension. In a recent *Nature* commentary, its creator argued that "[in] the current HDI, developed nations and oil-rich countries are placed highly without regard to how much their development paths cost the planet and imperil humanity's future development" and that "[the UN] should change the way it calculates the HDI. The revised index should include each nation's per capita carbon emissions, and so become a Human Sustainable Development Index" (Togtokh, 2011, p. 269).

The *Nature* commentary included no data. However, 2010 HSDI figures were posted on the United Nations University online outlet *OurWorld 2.0*, showing some interesting differences with the HSI: most notably the fall in the rankings of the USA, Canada, Australia, and of most oil-producer countries (Togtokh and Gaffney, 2010). Updated calculations for 2011 were subsequently posted on the *International Geosphere-Biosphere Programme* website.[1]

Despite some attention in the media (e.g., by the *Wired*[2] and *Telepolis*[3] magazines, and by a number of websites), up to now the HSDI has been largely ignored by the scientific community. This happened despite some interesting properties, including the fact that it derives from a highly recognized index and that it can be easily calculated from publicly available data: two elements that may overcome the lack of interest from outside the scientific world that characterizes many proposed indicators (see Smith et al., 2013). The lack of a proper scientific assessment of the HSDI probably depended on the fact that calculation details never appeared in a scientific outlet and that no systematic evaluation of its capacity to summarize sustainable development levels has been tried before. Given the importance of the HDI in the international discourse, amending it by introducing an environmental dimension may however represent the most straightforward way to move towards an influential sustainability index.

This paper aims at critically review the HSDI, presenting all the necessary calculation details and comparing it with a number of environmental indicators to understand its capacity to capture also the environmental side of sustainability. The remaining of the paper is structured as follows. The next section will define the HSDI and present a complete description of the procedure to compute it. Section 3 will introduce the 2012 HSDI, based on recently available UN data. Section 4 will critically assess its relation with other well

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[1] See http://www.igbp.net/5.20d892f132f30b443080002562.html.

[2] See http://www.wired.com/wiredscience/2011/11/global-sustainability-rankings/.

[3] See http://www.heise.de/tp/blogs/2/150933.

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known environmental indicators. Finally, Section 5 will discuss the results and propose a few amendment to the current index.

2. HSDI definition

The rationale behind the HSDI is to add an environmental dimension to the HDI – which already covers two of the three dimensions of sustainability, namely the social and the economic ones (see Goodland, 1995) – to build a true sustainable development index. The HDI includes three different series of data: life expectancy at birth, education (mean years of schooling and expected years of schooling), and income (GNI *per capita*). Following the technical notes of the last *Human Development Report* (UNDP, 2013), each of these "dimensions" is represented by a specific sub-index (I_{dim}) computed as

$$I_{dim} = \frac{x - \min}{\max - \min} \tag{1}$$

where x is the observed value for a given country, maxima are computed as the highest observed values in the 1980–2012 period and minima refer to somewhat arbitrarily defined "subsistence values" equal or below the minimum observed values: 20 years of life expectancy, zero years of schooling and 100 PPP Dollars of income in the 2013 report. The three dimension indexes are first separately computed, the HDI is then simply their geometric mean. Since all three dimension indexes fall by construction between zero and one, the HDI is limited in the same interval with greater values indicating higher development levels.

The HSDI adds an environmental dimension to the HDI, namely *per capita* CO_2 emissions. The corresponding index is computed by taking the complement to one of Eq. (1) to reflect the fact that higher emissions mean a poorer environmental performance. In formulae,

$$I_{emissions} = 1 - \frac{x - \min}{\max - \min} = \frac{\max - x}{\max - \min} \tag{2}$$

with the maximum corresponding to the highest observed value in the 2000–2009 period and the minimum set to zero, i.e., representing a fully decarbonized economy. Then, in analogy with the HDI, HSDI values are computed as

$$\text{HSDI} = \sqrt[4]{I_{life} \cdot I_{education} \cdot I_{income} \cdot I_{emissions}} \tag{3}$$

All four dimensions hold the same weight in the HSDI, which ranges in the [0, 1] interval with higher values meaning both higher standards of living and lower emissions.

3. The 2012 HSDI

We updated previous HSDI calculations using data included in the 2013 *Human Development Report* (UNDP, 2013) along with the latest available emission figures. HDI data refer to 2012 and were downloaded from the UNDP database (http://hdr.undp.org/en/statistics/hdi/). Data on CO_2 emissions stemming from the burning of fossil fuels and the manufacture of cement are measured in metric tons *per capita* and refer to 2009. They were downloaded from the World Bank database (http://data.worldbank.org/indicator/EN.ATM.CO2E.PC).

The 2012 HSDI was computed using the procedure above and resulted in 185 observations covering most world countries (all results are enclosed as supplementary data). The country with the highest HSDI is Norway (0.93), while the one showing the lowest value is the Democratic Republic of Congo (0.41). The average is 0.72 and the index distribution is significantly left skewed ($G_1 = -0.58$).[4]

Geographically, most high HSDI countries are European ones, with the noteworthy exceptions of New Zealand, Hong Kong and Japan. Sub-Saharian Africa and Southern Asia instead host the majority of low-ranked countries.[5]

Despite the introduction of the environmental dimension, the HSDI remains highly correlated with the HDI (Fig. 1). The correlation is almost perfect for HDI values below 0.7 ($r = 0.998$), with poor, low-emission countries uniformly improving their scores, while more "noise" is present above this threshold ($r = 0.837$), showing the existence of different development trajectories once basic needs are satisfied (Fig. 1, upper-left scatterplot).

It is worth noting that the three socio-economic dimensions of the HDI (and hence of the HSDI) are strongly and positively correlated and that CO_2 emission correlates with income as well. As a consequence, the emission index *negatively* correlates with all other dimensions (Fig. 1), which means that a trade-off exists between the human and the environmental dimensions of the HSDI. The developed countries that better succeeded in reducing this trade-off (e.g., Norway, New Zealand and Sweden) are the ones scoring better on the new index, while some of the HDI leaders with economies heavily dependent on fossil fuel consumption fell way down the rankings (e.g., Australia, USA and most oil-producing countries).

4. Comparison with other indicators

To asses how the HSDI captures the environmental dimension of sustainability, we compared it with a number of environmental indicators commonly estimated at the country level. For all variables, the most recent estimates were used (see also the supplementary data).

- The *Ecological Footprint* (EF) estimates the burden on natural systems of consumption processes. The EF is measured in global hectares (gha) *per capita*. EF data include 180 observations, refer to 2008 and were downloaded from the Global Footprint Network website (Global Footprint Network, 2012).
- The *Biocapacity* estimates the biological productivity of natural and man-managed systems. More specifically, biocapacity is an measure of the amount of bioproductive land available, where "bioproductive" refers to land and water areas that support significant photosynthetic activity and accumulation of biomass (Ewing et al., 2010). The biocapacity is measured in gha *per capita*, just as the EF. Data include 180 observations, refer to 2008 and were downloaded from the Global Footprint Network website (Global Footprint Network, 2012).
- The *Ocean Health Index* (OHI) is an adimesional index, ranging from 0 to 100, measuring the status of ten diverse public goals for healthy coupled human-ocean systems (Halpern et al., 2012). Data refer to 2012 and were computed for every coastal country, resulting in 119 observations included as supplementary information in Halpern's article.
- *Terrestrial and marine protected area* data measure the totally or partially protected areas of at least 1,000 hectares in a given country. The index is compiled by the United Nations Environmental Program-World Conservation Monitoring Centre and encompasses areas enjoying different levels of protection (see Bertzky et al., 2012). Data refer to 2010 and report the percentage of protected area in each country. They include 182 observations and were downloaded from the World Bank database (http://data.worldbank.org/indicator/ER.PTD.TOTL.ZS).

[4] All statistical analyses were performed using the *R* platform, version 2.15.1 (R Core Team, 2012).

[5] See also the map in Fig. 4a.