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METHODS

A comprehensive index for a sustainable society: The SSI — the Sustainable Society Index

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ABSTRACT

In search of an adequate set of indicators to measure the level of sustainability of a country, the main existing indexes have been examined. However, the conclusion must be that none of them seem to fit our needs completely. The main shortcomings are a limited definition of sustainability, a lack of transparency and an absence of regular updates. For this reason, a new index — the Sustainable Society Index (SSI) — has been developed. The SSI integrates the most important aspects of sustainability and quality of life of a national society in a simple and transparent way. Consisting of only 22 indicators, grouped into 5 categories, it is based upon the definition of the Brundtland Commission, extended to the Brundtland+ definition by explicitly including the social aspects of human life.

Using data from scientific institutes and international organizations, the SSI has been developed for 150 countries for which the SSI could be calculated. The resulting SSI scores allow a quick comparison between countries and — as two-yearly updates become available — show developments over time. The underlying data allow in-depth analysis of the aspects that cause the differences between countries.

This article outlines the development of the SSI and the calculation methodology as well as giving the main results. It also summarizes the need for further research and development of the SSI.

1. Introduction

Sustainability is very much in the spotlight these days. The mission of Al Gore and his film AnInconvenient Truth has contributed greatly to the present, widespread sense of urgency. However, this feeling is mainly confined to climate change. But sustainability is more than climate change, however dramatically climate change might affect our future. Few people experience the same sense of urgency with respect to sustainability in its wider sense.

The notion of what is meant by sustainability varies considerably. Even among scientists there are numerous definitions of sustainability (Pearce, not dated). To be able to support a sustainable way of living on our planet, a clear definition of sustainability is required. Moreover, one has to be able to measure the present level of sustainability and indicate how far removed we are from complete sustainability (Lawn, 2004). This need was clearly recognized by Hales and Prescott-Allen (2002) when they stated: 'Achieving sustainability requires defining its components in measurable terms and

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clearly fixing the responsibility to assess progress comprehensively.' In an attempt to meet the aforementioned challenges, the authors propose a comprehensive definition of sustainability and a corresponding new set of indicators, as described in this paper.

In Section 2 existing sets of indicators are examined. The conclusion is that none of these seem to fit our needs completely, making it necessary to develop a new set. This development is outlined in this section. Section 3 describes the methodology of calculating the indicators and of aggregating the results first into categories and then into one index. A preliminary sensitivity analysis for the attached weights for the aggregations is given. Section 4 gives the main results for all 150 countries, shown on world maps and in some spider webs. Section 5 outlines proposals for future use of the SSI. Section 6 gives the main subjects which are proposed for further research and development of the SSI. A conclusion is given in Section 7.

2. Sustainability and its indicators

2.1. *Definition of sustainability*

For many people, the basic idea of sustainability focuses greatly on depletion of resources. Others consider that sustainability covers also (irreversible) pollution, conservation of nature and other environmental and ecological aspects. Some include the aspects of quality of human life, the human well-being. From an anthropocentric point of view, sustainability comprises all three elements:

1. depletion of resources → in order not to leave future generations empty-handed,
2. environmental and ecological aspects → in order to enable present and future generations to live in a clean and healthy environment, in harmony with nature,
3. quality of life → in order to ensure human well-being for present and future generations.

All three elements are important for developing towards a sustainable society. It is for this reason that the IUCN, UNEP and WWF defined sustainable development as 'Improving the quality of life of humans while living within the carrying capacity of supporting ecosystems' (IUCN, 1991). The reason obviously being that sustainability without quality of life makes no sense and quality of life without sustainability has no perspective.

Another element, economy, is not explicitly included, though politicians often use the term 'sustainable economy'. However, the development of an economy is certainly not a condition for sustainability nor a goal. The economy of a country has to be developed within the limits set by sustainability.

The well-known and worldwide respected definition of the Brundtland Commission (WCED, 1987) has been interpreted in more than two hundred ways (Mebratu, 1998; Solow, 1993; Pezzey, 1989). To make explicitly clear that sustainability includes all the three elements mentioned above, we have extended the definition of Brundtland by adding a sentence so that the qualitative aspects of human life are explicitly included. We have formulated the Brundtland+ definition as follows:

A sustainable society is a society

- that meets the needs of the present generation,
- that does not compromise the ability of future generations to meet their own needs,
- in which each human being has the opportunity to develop itself in freedom, within a well-balanced society and in harmony with its surroundings.

To be able to measure the extent of sustainability we have elaborated the Brundtland+ definition into five distinct elements: a sustainable society is a society in which every human being

- is able to develop itself in a healthy manner and to obtain
- proper education,
- lives in a clean environment,
- lives in a well-balanced and safe society,
- uses non-renewable resources in a responsible manner so that future generations are not left empty-handed and
- contributes to a sustainable world.

The research question is now: is there a set of indicators available to measure these five elements adequately?

2.2. *Relevant existing indicators*

Many sets of indicators exist already and it seems that every year new ones are being developed. This suggests that either no single one is completely adequate or that every set serves a more or less different purpose. We have briefly examined the most relevant indexes and sets of indicators concerning sustainability on a national level. Our findings are shown in Table 1. We have summarized their pros and cons, bearing in mind the Brundtland+ definition of sustainability given above.

The overall conclusion is that none of the existing indexes seem to fit our needs completely. In other words, not one gives a complete and good insight into all relevant aspects of sustainability in a transparent, simple and easily understandable way, showing at a glance to what extent a society is sustainable or not. So a new index had to be developed, based on a set of indicators in accordance with the definition of Brundtland+.

2.3. *Criteria for indicators*

Indicators have to be chosen carefully, meeting the following criteria (Nagelhout, 2006; Bell and Morse, 2003; Meadows, 1998; Guy and Kibert, 1998):

- an indicator must be relevant for an issue according to the definition used;
- an indicator must be measurable;
- indicators have to be independent from each other and must have no mutual overlap;
- data for the indicators must be available from public sources, scientific or institutional;
- data must be available for all countries, at least for all but the smallest countries;

Table 1 – Relevant indexes and indicators on national level

1. Human Development Index
Developed by the UNDP (2005), published every year. Comprises four sets of data: life expectation at birth, adult literacy rate, combined gross enrolment ratio for primary, secondary and tertiary schools and GDP per capita. HDI covers only a minor part of all aspects of sustainable development (Neumayer, 2001).
Conclusion: HDI is very suitable for giving a rough idea of the level of development, though not on the sustainability of the development, particularly in developing countries. For developed countries the HDI is less valuable due to the limited information it contains.

2. Environmental Sustainability Index, ESI-2005
Developed by Columbia University and Yale University, USA, (Esty, 2005). Previous editions in 2001 and 2002. ESI comprises no less than 76 variables, which are aggregated into 21 indicators, resulting in 5 categories. ESI covers the whole range of aspects of sustainable development in its broad context. However, the Gender-Related Index is absent in the ESI and Good Governance receives only minor attention.
Conclusion: ESI supplies a lot of relevant and valuable information, but is not very transparent due to the great amount of data. It is uncertain whether an update will be made.

3. Environmental Performance Index, EPI-2006
Developed by Columbia University and Yale University, USA (Esty, 2006). Published in 2006 in order to present a better insight into the 'environmental dimension' of the Millennium Development Goals. The EPI will be developed further. EPI comprises 6 categories (Environmental Health, Biodiversity and Habitat, Sustainable Energy, Water Resources, Air Quality, Productive Resource Management), derived from 16 indicators.
Conclusion: the EPI — as the name already suggests — only partly covers sustainable development in its broader context.

4. Commitment to Development Index, CDI-2006
Set up by the Center for Global Development (2007), an independent, not-for-profit organization in the USA. Publishes the CDI every year since 2003. The CDI reviews for 21 rich countries the level of support given to poor countries to realize prosperity, good governance and security. It is composed of seven components: aid, trade, investment, migration, environment, security, and technology.
Conclusion: the CDI covers sustainable development only partly and offers information concerning no more than 21 countries.

5. Index for Sustainable Economic Welfare, ISEW
Calculated for over 10 countries, according to the design of Daly and Cobb (1989). The idea of the ISEW is to adjust the Gross Domestic Product of a country for costs that are currently not included in the GDP and/or are consciously shifted to the future (costs of environmental pollution, depletion of resources, costs of traffic accidents, but also matters like domestic and voluntary labor). Results are expressed in dollars.
Conclusion: very valuable as a correction on the GDP. It shows clearly that we are misleading ourselves by taking GDP as a standard. It does not include the main aspects of quality of life and does not offer a clear insight into the level of sustainability of a country. The ISEW is available for a limited number of countries only.

6. Genuine Progress Indicator, GPI
The GPI and ISEW are both variants of the 'green GDP'. The GPI has been developed by Redefining Progress and was published for the first time in 1998. Its increasing importance is being recognized (Talberth et al., 2006; Lawn, 2003; Anielski and Rowe, 1999). The same remarks made regarding the ISEW apply to the GPI.

7. Ecological Footprint
Developed by Wackernagel and Rees (1996), published every two years by the WWF in the Living Planet Report (WWF, 2006). Converts everything a person consumes (house, mobility, energy, food, recreation, etc.) and what is needed to produce all these items, into the required area on earth, the number of hectares per capita. The Ecological Footprint only partly covers sustainability in its wider sense. There is still quite some discussion about the calculation methodology used (Van den Bergh and Verbruggen, 1999).

Table 1 (*continued*)

7. Ecological Footprint (continued)
Conclusion: a valuable index for providing a quick and inspiring idea about the seriousness of the present lack of sustainability. Encourages people to take action. However, the Footprint is not suited for giving a good idea of sustainability in its broader sense.

8. Wellbeing of Nations
Set up by Robert Prescott-Allen (2001), in cooperation with international institutes. Up till now, published only once. Consists of the Human Wellbeing Index and the Ecosystem Wellbeing Index. Both comprise 5 categories, each based upon several indicators. Covers the whole field of sustainable development. Gives an enormous amount of information, which makes it rather complicated. The way of presentation hampers its accessibility and therefore its use.
Conclusion: excellent, though rather complicated index, published only once to date.

9. Millennium Development Indicators
Set up by the UN (United Nations, 2005) in order to monitor progress of achieving the Millennium Development Goals (1990–2015). Offers a lot of useful information. However, these indicators have a different goal than measuring the level of sustainability of a country. They do not cover the entire concept of a sustainable society.
Conclusion: valuable set of indicators, excellent for monitoring the effectiveness of policy with respect to the MDGs. Limited usefulness for a good insight into the level of a country's sustainability.

10. Indicators for the EU Sustainable Development Strategy
The set of indicators will be updated by the end of 2007 (UNECE, 2007). The present list of indicators will be condensed to around 100. The EU aims at a set consisting of 3 levels, the first two being the most important for policymakers. These two levels will probably comprise some 50 indicators. With an eye on the Lisbon Strategy, among other things, the set comprises many macro-economic indicators.
Conclusion: the set consists of a large number of indicators, including a number of indicators which are not much related to sustainability, like Gross Domestic Product and Official Development Assistance, while other issues only get minor attention or are missing, like Gender-related development and Access to drinking water. The set is limited to the EU-member countries.

11. CSD indicators
This set, developed by the UN Commission on Sustainable Development (United Nations, 2007), is published annually since 2003. The set comprises 14 themes, 44 sub-themes, 50 core indicators, and 46 other indicators. The set offers much information. However, some of the indicators are hardly, or not at all, related to sustainability, like GDP, ODA and Tourism. Some indicators are missing, like the important Gender Equality and Sufficient Food, while others are only partly included (Good Governance, International Cooperation, Waste Recycling).
Conclusion: many indicators give a lot of information, but they do not completely cover sustainability in its broadest sense.

- data must be reliable;
- data must be recent and be regularly updated.

With respect to the resulting set of indicators, criteria can also be formulated:

- the set of indicators has to be easily accessible, also for the general public. This means that the number of indicators must be limited;
- the set of indicators must cover the whole field of sustainability, in line with the definition used;
- the indicators have to be neatly arranged, in an easily understandable framework, in order to ensure ease of use;

- the total set of indicators must give a good insight into the present situation with respect to sustainability, and indicate the gap between the present situation to the situation of complete sustainability;
- the set must enable the comparison between countries.

One interesting criterion — people's involvement — is not included in our list. Not because this is not important. On the contrary. However, since the SSI is primarily intended to be used at national and international level, and in view of all research which has been done on this subject already, we have chosen a top-down approach. Nevertheless, people — in the first place politicians and government officials — play an important role when defining short-term and long-term goals. Moreover, every country will likely add one or more tailor-made indicators, covering country-specific circumstances or issues.

2.4. *New set of indicators*

Following the interpretation of Brundtland+ and taking into account the criteria for the indicators as shown in Section 2.3, the following 22 indicators can be defined. These indicators are clustered in 5 categories, following the elaboration of the Brundtland+ definition, as given at the end of Section 2.1.

I Personal Development
1 Healthy Life
2 Sufficient Food
3 Sufficient to Drink
4 Safe Sanitation
5 Education Opportunities
6 Gender Equality
II Clean Environment
7 Air Quality
8 Surface Water Quality
9 Land Quality
III Well-balanced Society
10 Good Governance
11 Unemployment
12 Population Growth
13 Income Distribution
14 Public Debt
IV Sustainable Use of Resources
15 Waste Recycling
16 Use of Renewable Water Resources
17 Consumption of Renewable Energy
V Sustainable World
18 Forest Area
19 Preservation of Biodiversity
20 Emission of Greenhouse Gases
21 Ecological Footprint
22 International Cooperation

These 22 indicators and 5 categories constitute the newly proposed Sustainable Society Index, the SSI-2006. Table 2 gives the rationale for the selected indicators.

2.5. *Indicators which have been left out*

2.5.1. *GDP per capita*

The most well-known indicator — GDP per capita (Gross Domestic Product per capita) has been left out, for obvious reasons (Van den Bergh, 2007). This is not surprising, since Economy is not explicitly included in the definition.

Very few people still consider GDP per capita to be a useful indicator for development towards sustainability. In that respect, other indicators, such as the ISEW (Daly and Cobb, 1989; Bleys, 2008) or the Dutch DNI (Duurzaam Nationaal Inkomen, Sustainable National Income) (Hueting, 1980), are

Table 2 – Rationale for each indicator

Indicator	Rationale
1 Healthy Life	Condition for development of each individual in a healthy way
2 Sufficient Food	Condition for the development of an individual
3 Sufficient to Drink	Condition for the development of an individual
4 Safe Sanitation	Condition for the prevention and spreading of diseases that would severely hamper a person's development
5 Education Opportunities	Condition for a full and balanced development of children
6 Gender Equality	Condition for a full and balanced development of individuals and society at large
7 Air Quality	Condition for human and ecological health
8 Surface Water Quality	Condition for human and ecological health
9 Land Quality	Condition for production of crops, livestock and timber
10 Good Governance	Condition for development of all people in freedom within the framework of (international) rules and laws
11 Unemployment	Access to the labor market is a condition for well-being for all people
12 Population Growth	Limitation of population pressure on earth is a condition for sustainability
13 Income Distribution	Fair distribution of prosperity is a condition for sustainability
14 Public Debt	Measure of a country's ability to make independent decisions with respect to budget allocation
15 Waste Recycling	Measure of sustainable use of raw materials in order to prevent depletion of resources
16 Use of Renewable Water Resources	Measure of sustainable use of water resources in order to prevent depletion of resources
17 Consumption of Renewable Energy	Measure of sustainable use of energy resources in order to prevent depletion of resources
18 Forest Area	Preservation of forest area is a condition for sustainability
19 Preservation of Biodiversity	Condition for perpetuating the function of nature, in all its aspects
20 Emission of Greenhouse Gases	Measure of main contribution to climate change, causing un sustainable effects
21 Ecological Footprint	Measure of people's (un)sustainable usage of the earth's resources
22 International Cooperation	Measure of a country's willingness to take up its responsibility for the world at large with respect to sustainability

far more indicative. Unfortunately, they cannot be used for the SSI, since these two indicators are available for no more than a couple of countries.

2.5.2. *Depletion of resources*

Depletion of resources is also not included in the SSI. Contrary to the GDP, this item should be included. However, it is impossible to do so due to a lack of data. The amount of economically exploitable resources varies with the development of technology and market prices. Thus, no reliable and useful data is available to analyze the depletion of resources. An indication of the depletion could come from data about material consumption. However, this data is available for a limited number of countries only.

2.6. *Comparison of the indicators with the criteria*

Comparison of the selected indicators with the criteria outlined above in Section 2.3 shows that all indicators meet most of the criteria. However there are a few deviations.

2.6.1. *Independency*

There are two indicators that — without a doubt — do not completely meet the criterion of independency. The first is the Ecological Footprint. The value of the Ecological Footprint consists for more than 50% of energy use. This means that there is a substantial overlap with Consumption of Renewable Energy (indicator 17). However, we have included the Ecological Footprint in our set since it is the only readily available indicator that gives some indication of the extent of human consumption and depletion of resources for all 150 countries. The same overlap applies, to a lesser extent, for the indicators Forest Area and Preservation of Biodiversity. Another overlap exists between Consumption of Renewable Energy and Emission of Greenhouse Gases. Both are included in the SSI from a different point of view, as outlined in Table 2. However, the effects of this overlap and the resulting double accounting problems need further research. One might assume that the two indicators Sufficient Food and Sufficient to Drink are greatly interrelated. A brief assessment of the data certainly does not support this assumption.

2.6.2. *Recent date*

Data from 2005 is available for only a few indicators. There are even some indicators whose most recent data pre-dates 2000.

2.6.3. *Reliability of data*

This is a serious concern, and one which requires further examination. However, reliability will increase over time, due to the improvement of statistical offices around the world and the application of generally accepted rules.

3. Calculation methodology

3.1. *Selection of countries*

The Sustainable Society Index has been developed for as many countries as possible. This offers the option for comparison between countries using various viewpoints: neighboring countries, more or less similar countries, regional comparisons, comparisons between rich countries like the OECD members, comparison between North and South, etc. However, 43 of the existing 193 countries had to be left out due to a lack of data. The criterion for the inclusion of a country in the SSI has been that data for at least 12 out of 22 indicators for that country was available. By doing so, the set of indicators and the SSI could be calculated for nearly all big and medium-sized countries. Exceptions to the bigger countries are Afghanistan, Djibouti, Eritrea, Somalia and Surinam. Besides these, most small island states had to be left out. In this way, the SSI could be calculated for 150 countries.

3.2. *Calculation of indicators*

3.2.1. *Data*

For the calculation of the indicators of the SSI, only data from public sources has been used. If data was missing, no additional field work was done. In that case, the average of data of this indicator of comparable countries has been used. To define 'comparable' countries, the classification in seven clusters as specified for the ESI has been used (Esty, 2005).

3.2.2. *Sustainability value*

The sustainability value of each of the 22 indicators is the value for the level at which full sustainability is achieved. The sustainability value is the final goal for an indicator. It is remarked that the sustainability value cannot always be determined objectively, nor will it always be a constant value over time. Full sustainability will be achieved when a country scores the sustainability value for each indicator. The difference between the current value of an indicator and the sustainability value gives the distance to sustainability. This is visualized in Fig. 1 for the Netherlands.

For a number of indicators, the sustainability value can be determined objectively. For instance, the number of undernourished people has to be 0 (indicator 2), or the percentage of people with access to safe drinking water has to be 100 (indicator 3). This reasoning applies for indicators 2, 3, 4, 5, 6,

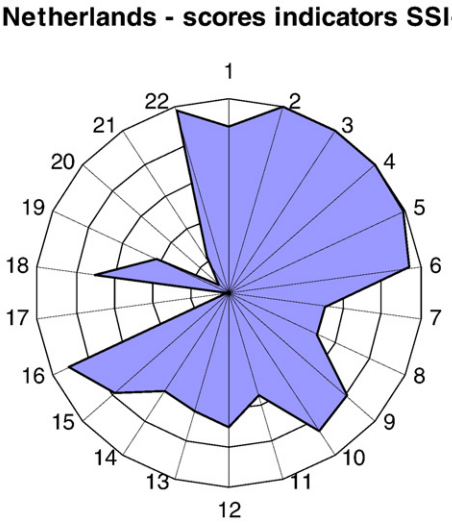

Fig. 1 – Distance to sustainability for the Netherlands for the 22 indicators.

15, 17 and 22. However, some might question why the gender equality has to be 1. So even in this rather obvious case, some subjectivity is included.

For some indicators the sustainability value is less obvious and probably cannot be determined in a detached manner. When is population growth sustainable? If the number of inhabitants stays constant? Or only when it declines? And at which percentage does it have to decline to be sustainable? Or when is income inequality sustainable? Moreover, the sustainability value of an indicator may vary over time. For instance population growth: currently our planet seems to be rather overpopulated. However, it can very well be that one's view on this issue will change in the future.

3.2.3. *Calculating the indicators*

3.2.3.1. Sustainability value is known. If the sustainability value of an indicator is known, the value of the indicator is scored with a 10 in the case of 100% sustainability. If there is no sustainability at all, the value for the indicator is 0. The basic data for these indicators is transformed to the scale of 0 to 10 (Ebert and Welsch, 2004).

3.2.3.2. Educated guess for the sustainability value. For indicators 18, 20 and 21, an educated guess of the sustainability value is possible, as has been outlined in Table 3.

3.2.3.3. Sustainability value is unknown. Wherever even an educated guess is not possible, we have chosen to give the highest score of the 150 assessed countries for that indicator a 10 and the lowest score a 0. Often the calculated maximum value is slightly lower than 10, depending on the chosen formula, so the calculation does not have to be adjusted every time new maximum basic data is made available. The same applies for the calculated minimum values.

Table 3 – Educated guess for the sustainability value of some indicators

18. Forest area: It seems obvious to determine the present situation as sustainability value. That would mean that a country with a constant forest area would score a 10 for this indicator. However it is very questionable whether the present situation reflects sustainability. To answer that question we have to know how much area should be allocated for nature. Moreover, the question is whether it is correct that the sustainability value of a country is rewarded with a 10. That would mean that countries which are 'more sustainable than sustainable' cannot be rewarded for this contribution, allowing other countries to be less sustainable. Therefore a constant forest area in the period 1990–2005 is rewarded with a 7, an increase over 0.4‰ with a 10 and a decline over 0.65‰ with a 0.

20. Emission of Greenhouse Gases: At present, the generally accepted value of the sustainable level of emission of greenhouse gases is 2 ton CO2 per capita per year. A score of 8 is awarded for this sustainability value. So countries which are 'more sustainable than sustainable' can be rewarded.

21. Ecological Footprint: Taking the middle scenario for room for nature as a starting point, the present sustainability value — at the present number of 6.5 billion world inhabitants — is 1.2 ha per capita. The score for this sustainability value is 8, similar to Emission of Greenhouse Gases.

The transformation from basic data to indicator values has been done by standardization, apart from indicators 11, 13, 14 and 18. For these indicators, more complex formulas have been used, in line with the characteristics of the indicator.

The formulas used for all 22 indicators can be found on the website www.sustainablesocietyindex.com.

3.3. *Aggregation*

Opinions concerning aggregation vary enormously. For some it is an absolute 'don't', others simply do it (Ebert and Welsch, 2004). In view of the objectives of the SSI — among others to show at a glance the level of sustainability of a country — an aggregation has been made from indicators into categories and from categories into one single figure for the SSI.

One of the objections to aggregation is that it can be compared to adding apples and oranges. However, if one accepts the definition of sustainability that has been used for the SSI, all 5 categories and 22 indicators are essential for assessing a country's sustainability — no matter whether they are apples or oranges. The objective of a country is (or should be) to achieve full sustainability. This requires achieving the sustainability value for each indicator. So there can be no trade-off between two (or more) indicators or categories (Dietz and Neumayer, 2007).

In general, aggregating smoothes out possible extreme values, which then become less clear. The only answer to this reasonable remark is that it is important to look at the aggregated figures as well as at the underlying ones.

An essential question when considering aggregation is the attribution of weights. One may consider one indicator to be more important for achieving sustainability than another. However, due to a lack of a scientific basis for the attribution of different weights to the indicators, every indicator has received the same weight for the aggregation into categories.

The same procedure, for the same reason, could be applied for the aggregation of the five categories into one figure for the index. However, examining the impact of each category on sustainability of the own country and of the world at large, it is obvious that quality of life has it main effects — though certainly not all — within the own country, whereas sustainability also has serious effects on other countries and on the world at large. Therefore the three categories with emphasis on quality of life each received a weight 1/7; the two categories with emphasis on sustainability each received a double weight, 2/7. As yet there is no sound scientific theory to support this. However, this has been done since it seems to better reflect the relative importance of the latter two categories.

The complete set of data is available on the website www.sustainablesocietyindex.com, presented in an Excel spreadsheet (both in English and Dutch), which enables the interested reader to experiment with different weights.

3.4. *Sensitivity*

Since no solid scientific theory exists for the aggregation into categories and into one single index, we have analyzed the sensitivity of the results for the attribution of weights for the highest and the lowest-scoring countries.

Table 4 – Weights for aggregation from category to index

Category	Weight
Personal Development	1/7
Clean Environment	1/7
Well-balanced Society	1/7
Sustainable Use of Resources	2/7
Sustainable World	2/7

The complete results of the calculations applying the weight factors mentioned in the previous paragraph are shown in Appendix B. For the countries at the top and bottom of the ranking list the results are reproduced in columns 2 and 3 of Table 5. The double weights of the latter 2 categories in Table 4 may be expected to skew the results to a certain extent. Therefore, the calculation was repeated for two alternatives, in the first place by giving each of the five categories an equal weight. See columns 4 and 5. In the second place, the SSI was calculated as the unweighted average of all 22 indicators. These results are shown in columns 6 and 7 of Table 5.

3.4.1. *SSI calculated with equal weights*

Calculating the SSI by giving all five categories the same weight raises the average SSI score by 0.082 from 5.473 to 5.555, i.e. by 1.5%. However, the ranking is only slightly affected. At the top end, nothing changes very much, as can be seen in Table 5. At the sub-top, countries like Vietnam and Bhutan end up in a lower position. Their relatively high scores for the category Sustainable World brought these countries to the top of the SSI ranking list, due to the fact that this category has been given a double weight.

At the bottom of the list we see the same pattern. At the very bottom we mainly find the same countries. But Qatar, Kuwait and United Arab Emirates move to a higher position due to high scores for the Personal Development category. This does not apply to the same extent for Libya, since Libya scores much lower than these three countries on the Clean Environment and Well-balanced Society categories.

The biggest changes in SSI score are for Qatar (+ 0.92) and Burundi (– 0.68).

3.4.2. *SSI calculated as the unweighted average of all 22 indicators*

By calculating the SSI indirectly — as we have done: aggregating indicators into categories and then aggregating into the SSI — we have assigned more or less unnoticed weights. Since not every category comprises the same number of indicators, indicators making up a category with only three indicators receive a higher weight than indicators that are part of a category with six indicators. As might be expected, there is a greater difference compared with the SSI, calculated with weights as shown in paragraph 3.3, than if we give 'only' the categories the same weight. The average score is raised by 0.318, from 5.473 to 5.791, i.e. by 4.3%.

At the very top no changes occur; countries in the sub-top show a stronger tendency to slip to a lower position. At the bottom of the list we find slightly bigger changes. The biggest changes in SSI score are for the United Arab Emirates (+ 1.41) and the Democratic Republic of Congo (– 0.83).

A preliminary conclusion could be that the SSI is not very sensitive for the weighting of the categories; that is, for the weighting that we gave the categories. Other weightings are imaginable. Calculating the SSI as the unweighted average of all 22 indicators has slightly more effect.

4. Results of the SSI

4.1. *The SSI for 150 countries*

The world map shows at a glance the level of sustainability of 150 countries for which the SSI could be calculated. With a 7.0, Norway is number 1 on the SSI ranking list (see also Appendix B). The world at large scores lower than 6 on average. Western Europe and a couple of other countries, 27 in total, score 6.0 or above, a relatively positive score. However, even all these countries are way below the score of 10 for full sustainability. Many of the lower scores are for countries in Africa, the Middle

Table 5 – Sensitivity for the choice of weights

Country	SSI calculated with weights as shown in paragraph 3.3		SSI calculated with equal weights for each category		SSI calculated as unweighted average of the 22 indicators	
	Score	Rank	Score	Rank	Score	Rank
Highest scoring countries						
Norway	7.0	1	7.4	1	7.5	1
Switzerland	6.9	2	7.2	3	7.3	2
Sweden	6.8	3	7.2	4	7.3	3
Finland	6.7	4	7.2	2	7.3	4
New Zealand	6.7	5	7.1	5	7.3	5
Austria	6.7	6	6.9	6	7.1	6
Iceland	6.6	7	6.9	7	7.0	7
Vietnam	6.4	8	6.1	35	6.3	37
Georgia	6.3	9	6.3	21	6.5	31
Japan	6.3	10	6.8	15	7.0	8
Uruguay	6.3	11	6.4	19	6.6	22
Netherlands	6.2	12	6.5	12	6.8	13
Canada	6.1	13	6.7	9	6.8	11
Bhutan	6.1	14	5.9	42	5.8	66
Denmark	6.1	15	6.7	10	6.9	9
Lowest-scoring countries						
Uzbekistan	4.5	136	5.0	115	5.6	88
Syria	4.5	137	4.7	138	5.2	122
Iran	4.5	138	4.7	139	5.2	118
Egypt	4.5	139	4.8	130	5.4	99
Jordan	4.4	140	4.8	135	5.4	101
Malta	4.2	141	4.8	136	5.3	111
Yemen	4.1	142	4.2	148	4.6	143
Iraq	4.0	143	4.2	149	4.7	141
Qatar	4.0	144	4.9	122	5.4	102
Libya	4.0	145	4.5	143	5.1	127
Kuwait	3.9	146	4.8	125	5.3	113
United Arab	3.9	147	4.8	126	5.3	110
Turkmenistan	3.8	148	4.4	146	4.8	137
Oman	3.7	149	4.4	145	4.9	134
Saudi Arabia	3.4	150	4.0	150	4.5	147

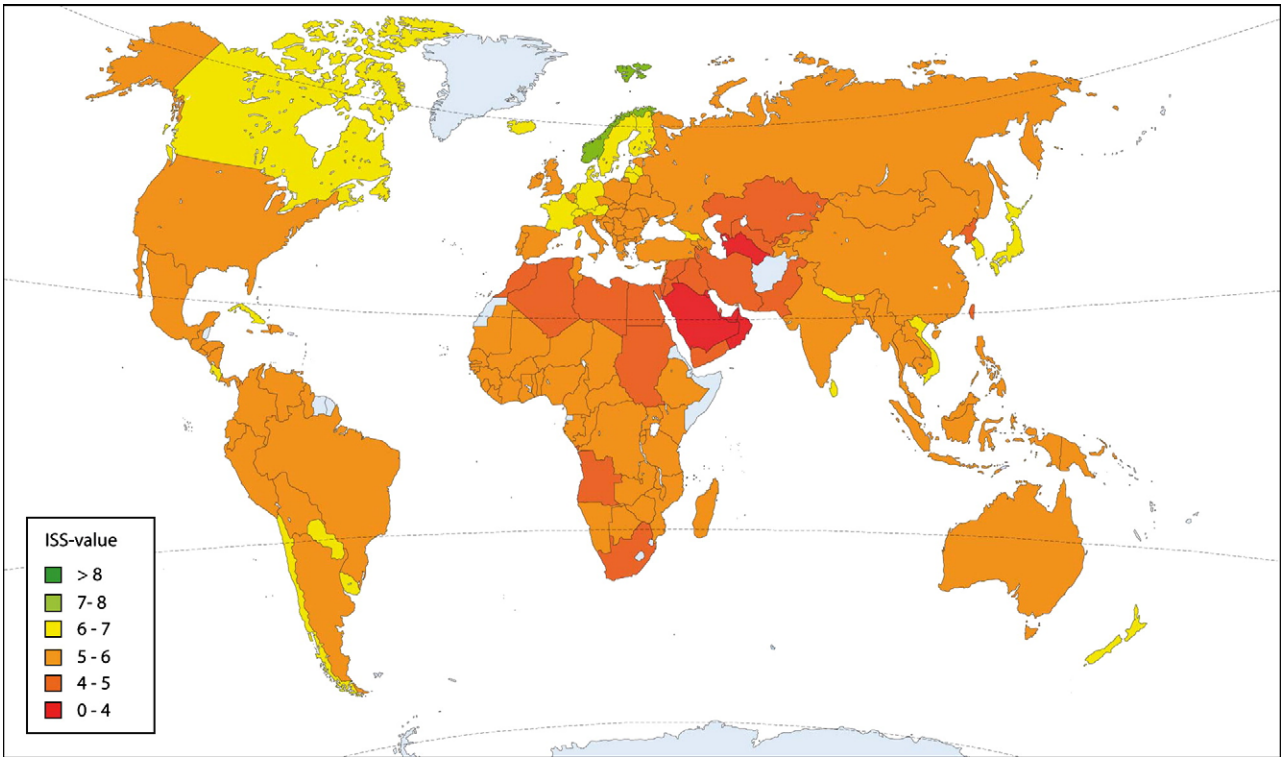

Fig. 2 – Overall SSI score.

East and Western Asia, with the oil-rich countries bringing up the rear (Fig. 2).

4.2. *Results for each of the 5 categories*

4.2.1. *Personal Development*

Large differences are found worldwide in Personal Development. 66 of the 150 assessed countries score an 8 (80% of the sustainability value) or above for this category. Out of 30 countries with the lowest scores, no less than 25 are found in Africa (Fig. 3).

4.2.2. *Clean Environment*

No more than 11 countries score a 7 or higher on Clean Environment, with Norway and Finland being the only ones scoring higher than 8 (Fig. 4).

At the top of the list we find many industrialized countries, but for example also two African countries: Congo and the Central African Republic. The 30 lowest-scoring countries do not — surprisingly? — include a single high-industrialized country. China is third from the bottom, just above Pakistan and Haiti.

4.2.3. *Well-balanced Society*

Norway tops the list for this category too. Among the top thirty, we also find Belarus. This last remaining European dictatorship takes 7th place, the dramatically low score for indicator 10 (Good Governance) notwithstanding. The high overall score is due to the good marks for the other 4 indicators, although they may possibly be overestimated (Fig. 5).

The final 30 places are all occupied by non-industrialized countries, among which the oil-rich countries Nigeria, Venezuela and Iraq. Bringing up the rear is Sierra Leone, partly due to very high unemployment and extremely unequal income distribution.

4.2.4. *Sustainable Use of Resources*

Iceland comes out best, thanks to a high score for both Use of Renewable Water Resources and Consumption of Renewable Energy (Iceland mostly uses hydropower and geothermal energy as energy sources). Kuwait takes last place with a score of a round zero. Worldwide, the use of resources is anything but sustainable. The Middle East, the countries around the Caspian Sea and countries in North Africa receive the lowest scores, often due to very low scores for all three indicators (Fig. 6).

4.2.5. *Sustainable World*

At the top of the list we find — quite surprisingly — India, followed by Vietnam and China. According to the available data, all three countries have extended their forest area, emit little CO_2 per capita, and have a small footprint. With their rapidly growing economies, particularly India and China cannot be expected to be able to maintain their top position (Fig. 7).

The rich OECD countries score badly with respect to Sustainable World. The highest scoring OECD country, Turkey, is found in 32nd position, and the next on the list, Italy, only at number 83. At the bottom of the list we find three oil-rich countries, followed by Australia, its low position being due to deforestation, high CO_2-emissions, and a large footprint.

Countries with a large forestry industry like Brazil and Indonesia — despite a zero for the indicator Forest Area — still score over 6 for this category due to the high score for the remaining 4 indicators.

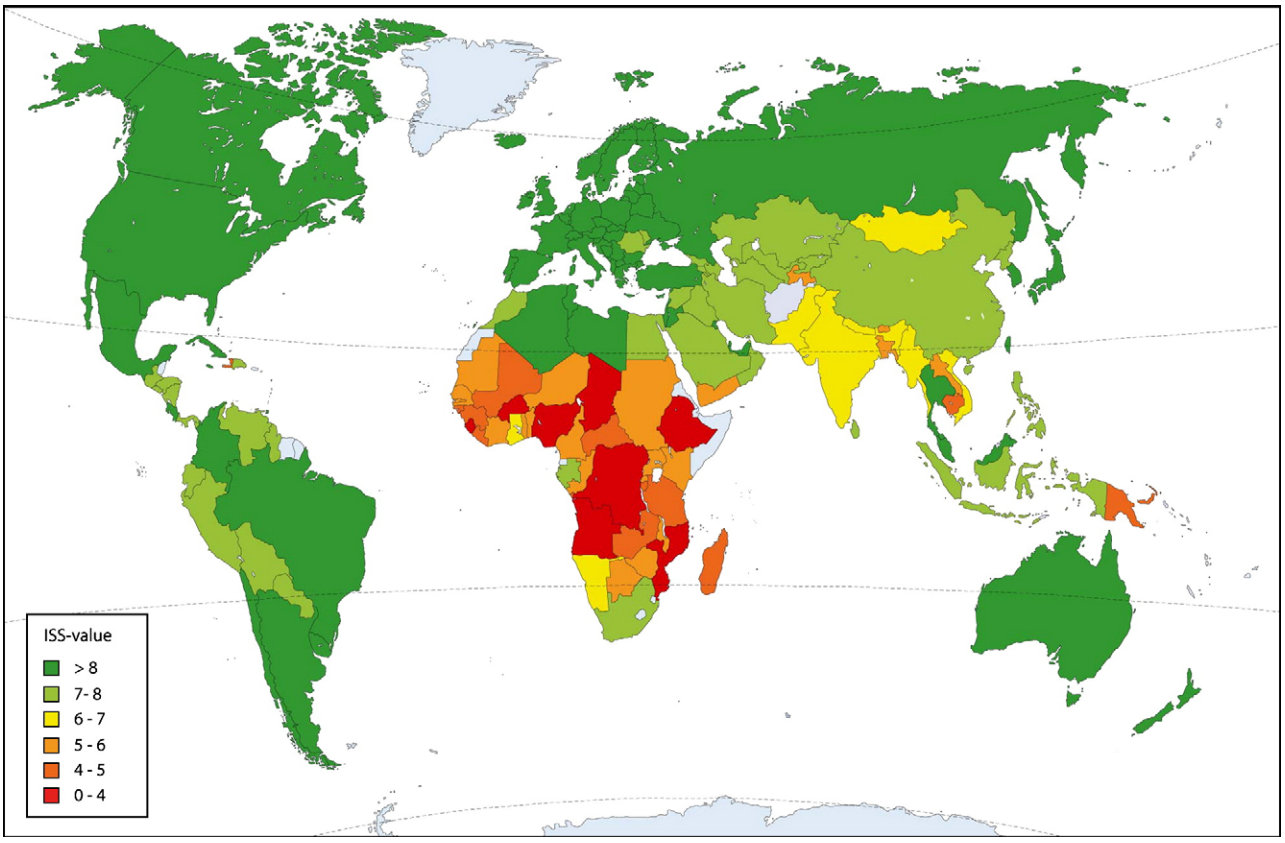

Fig. 3 – Scores for Personal Development.

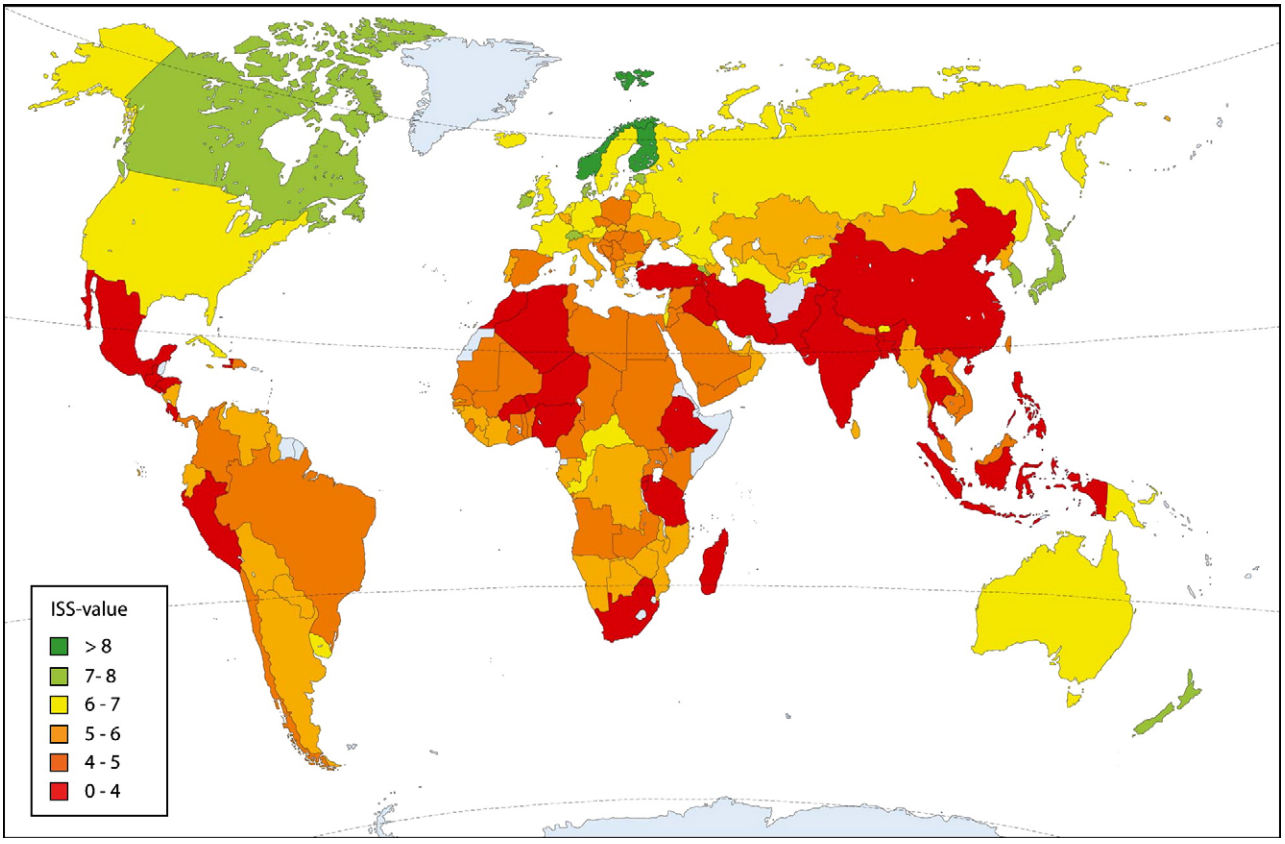

Fig. 4 – Scores for Clean Environment.

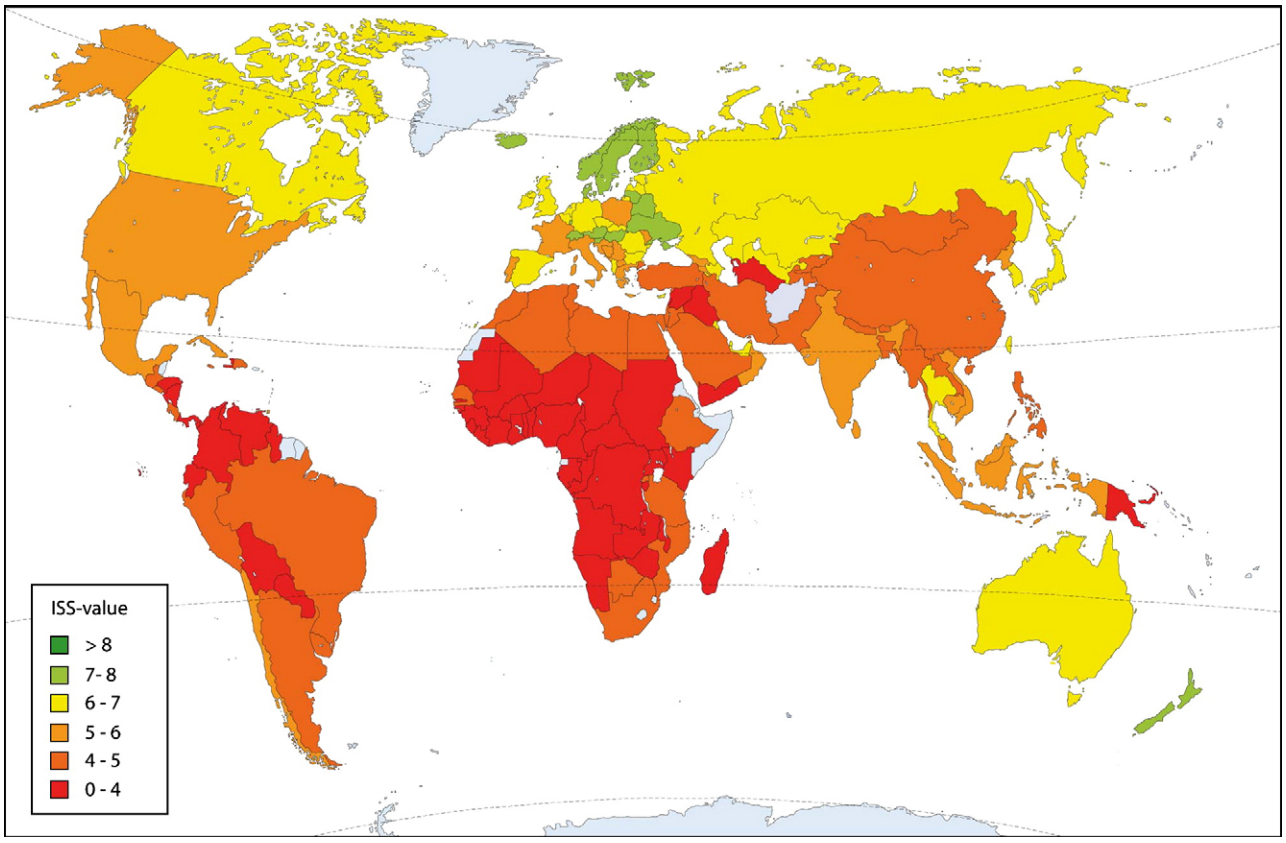

Fig. 5 – Scores for Well-balanced Society.

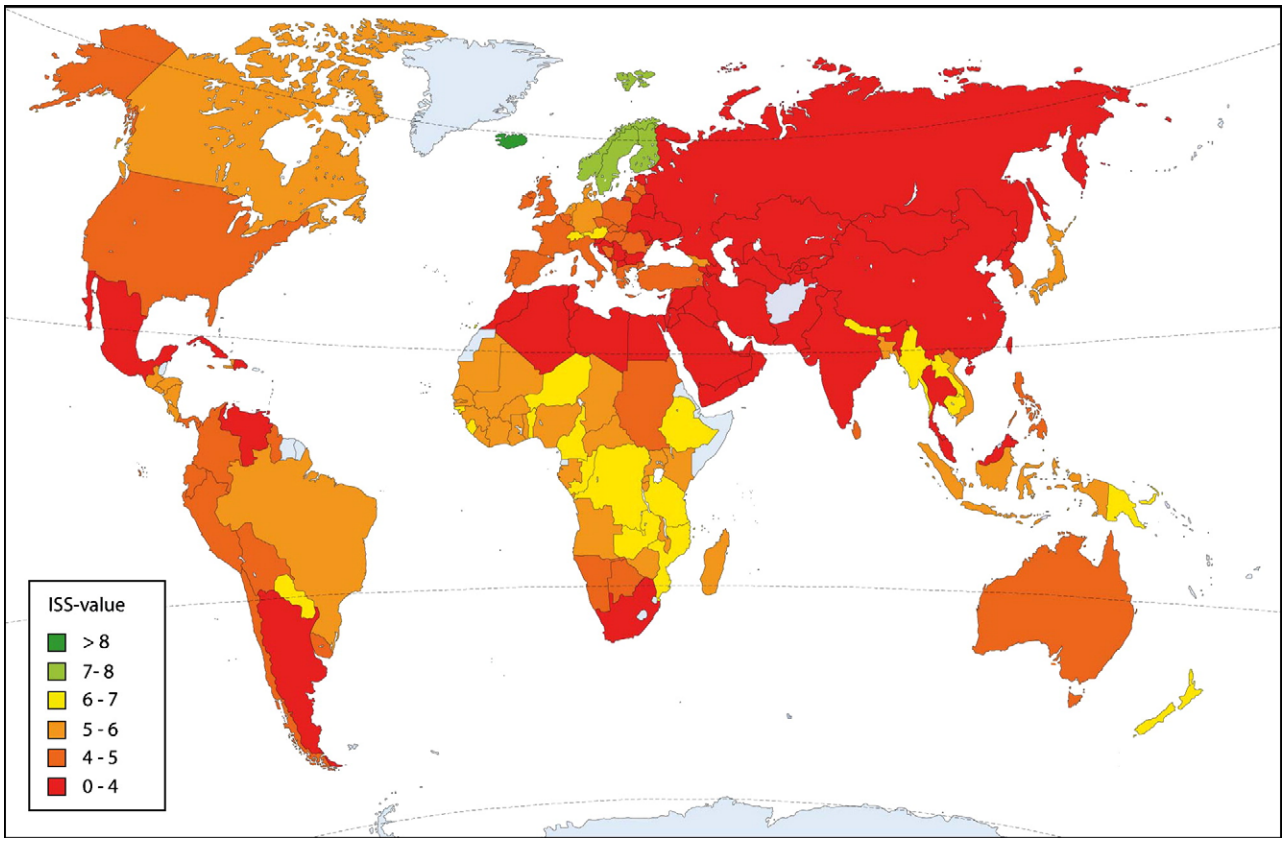

Fig. 6 – Scores for Sustainable Use of Resources.

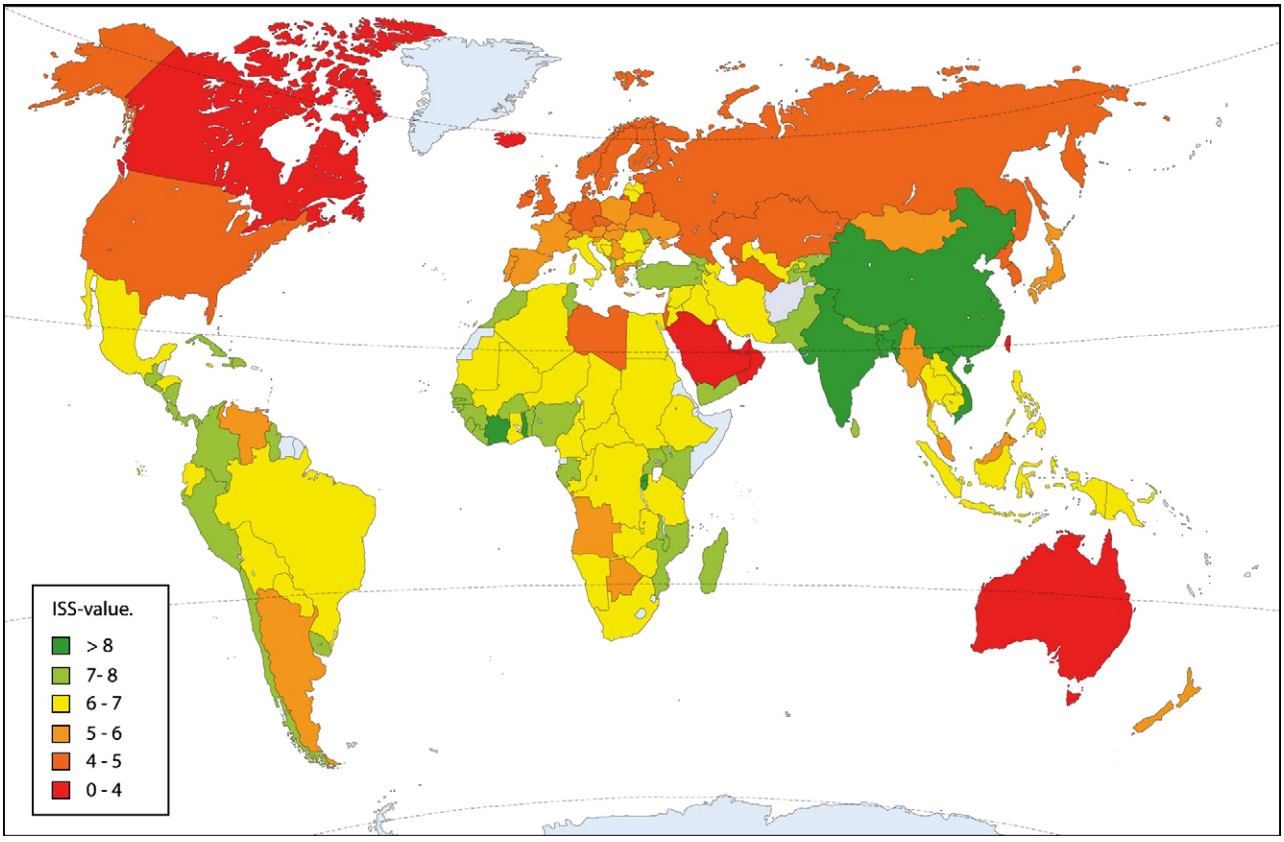

Fig. 7 – Scores for Sustainable World.

More details can be found on the website, www.sustainablesocietyindex.com (both in English and Dutch).

4.3. *Regional differences*

The results of the five categories for four regions are shown in spider webs (Figs. 8–11). This illustrates the great differences in development towards sustainability between the four regions. Europe scores relatively high on Personal Development, rather low on Well-balanced Society and Clean Environment, and very low on Sustainable Use of Resources and Sustainable World. Africa scores lower than Europe on all categories, apart from Sustainable World. Compared to Africa,

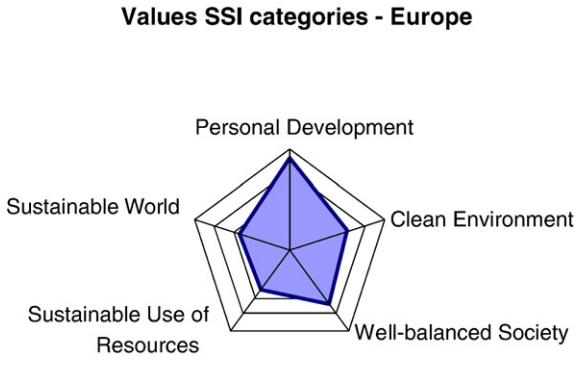

Fig. 8 – SSI categories — Europe.

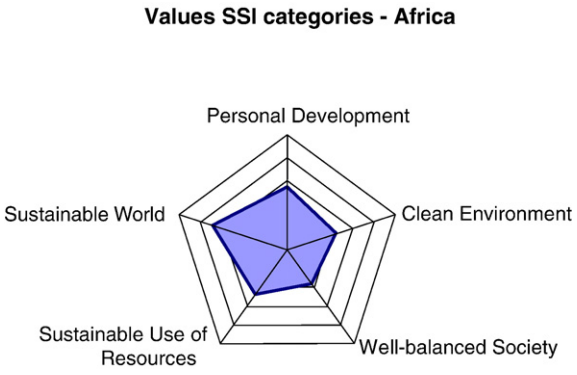

Fig. 9 – SSI categories — Africa.

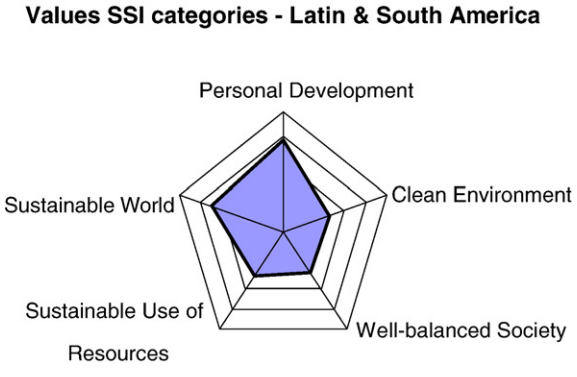

Fig. 10 – SSI categories — Latin and South America.

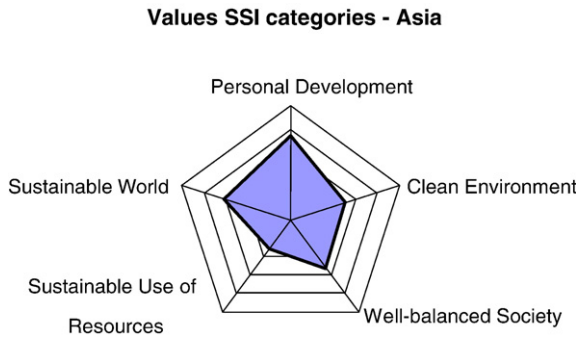

Fig. 11 – SSI categories — Asia.

Latin and South-America scores much better on Personal Development and also on Well-balanced Society. The other three categories differ only slightly. Asia shows a very bad performance on Sustainable Use of Resources.

5. Proposed use of the SSI

Having developed the SSI, several possible ways of using it are proposed:

1. To enlarge the awareness of people about the extent of sustainability and unsustainability of their own country.
2. To use it as a policy instrument for all government levels. For instance at national level, each indicator can be assigned to a specific ministry. This ministry will be responsible for the development towards sustainability with respect to this indicator. Frequent monitoring of progress will stimulate reaching the objectives set by the government.
3. To help NGOs with their strategy towards sustainability.
4. To aid easy communication between actor networks at all levels of human society.
5. To compare the scores of countries in order to learn from each other and to stimulate each other to make progress on the road to sustainability.
6. For educational purposes at all levels.

6. Further research and development on the SSI

Further research is required on several aspects of the SSI. Apart from the lessons that will be learned by using the SSI, research and development will be done on the following subjects:

1. To evaluate the relevance of each indicator.
2. To reconsider the three indicators that are related to energy (17, 20 and 21).
3. To define the sustainability values for those indicators whose sustainability values are as yet unknown, and to refine the sustainability values for the other indicators.
4. To evaluate the reliability of data.
5. To evaluate the calculation methods used, including the weights given to indicators and categories for calculating the SSI.
6. To analyze sensitivity of the assumptions used in the calculation of the SSI more extensively.
7. To develop the SSI for regional, sub-national levels.
8. To prepare the SSI for possible use for various branches (a test is now being executed for greenhouse culture).

7. Conclusion

It has been demonstrated that the SSI is a simple instrument for assessing a country's sustainability. The SSI, based on a solid definition, shows at a glance the present level of sustainability of a country and the distance to full sustainability. Since the SSI only has a limited number of indicators, it is easy to understand, to use and to maintain. The SSI offers a country a practical tool for defining targets on its way to sustainability and for monitoring the progress over time. The underlying data offer the opportunity to analyze differences between countries and thus provide additional stimuli for improvements.

The very reasonable question regarding the decision to develop a new index while so many exist already has been answered in Section 2 by reviewing the main existing indexes and sets of indicators — with respect to sustainability — on a national level. The preference of the SSI over existing indexes can be found in its transparency, its limited number of indicators, and therefore its ease of use. Furthermore, the SSI covers sustainability in its broadest sense, including social, environmental, ecological and institutional aspects, while most other indexes do so only partly. The complete data set and results of the SSI are available through the website (www.sustainablesocietyindex.com).

One of the main objections to the SSI is the aggregation of all indicators into one single figure for the index. Should one only consider this figure in isolation, the results may be misleading and can easily be misused. This objection is inextricably bound up with aggregation into one final figure. It stresses the importance of presenting all the results of the SSI — values of all indicators and categories — in a transparent and easily understandable way. Since the ultimate goal is to achieve a score of 10 — expressing full sustainability for each indicator — there can be no trade-off between the indicators or categories.

As outlined briefly in Section 6, further research is needed on several important items of the SSI. This will be done the months and years to come. The latest developments and results of research will be included in every two-yearly update of the SSI. Comments and suggestions are most welcome.

Appendix A

List of indicators (for calculation methodology, see www.sustainablesocietyindex.com)

1. *Healthy Life*: life expectation at birth in number of healthy life years — Hale. WHO, 2002.
2. *Sufficient Food*: number of undernourished people as percentage of the total population. FAO, 2000 – 2002.
3. *Sufficient to Drink*: number of people with sustainable access to an improved water source as percentage of the total population. WHO, 2002.

4. *Safe Sanitation*: number of people with sustainable access to improved sanitation as percentage of the total population. WHO, 2002.
5. *Education Opportunities*: combined gross enrolment ratio for primary, secondary and tertiary schools. Unesco, 2002/2003.
6. *Gender Equality*: Gender-Related Development Index. UNDP, 2003.
7. *Air Quality*: air quality with respect to concentration of NO2, fine particulate matter and indoor air pollution from solid fuel use. ESI, 1993–2004.
8. *Surface Water Quality*: Surface Water Quality based on dissolved oxygen concentration, electrical conductivity, phosphorus concentration and concentration of suspended solids. ESI, 1993–2003.
9. *Land Quality*: degraded land as percentage of cultivated and modified land, the LQ-score. HWI, about 1997.
10. *Good Governance*: the average of the values of the 6 Governance Indicators of the World Bank. World Bank, 2004.
11. *Unemployment*: employment as percentage of total labor force. ILO, 2000–2004.
12. *Population Growth*: average population growth in the period 2000–2005. UN Population Division, 2002.
13. *Income Distribution*: income of the richest 10% to the poorest 10% of the people in a country. HDR, 1989 to 2003.
14. *Public Debt*: the level of public debt — and if this figure is lacking, the foreign debt — of a country as percentage of Gross Domestic Product. IMF, 2005.
15. *Waste Recycling*: amount of recycled solid waste as percentage of the total amount of solid waste. ESI, 1996–2003.
16. *Use of Renewable Water Resources*: water consumption per year as percentage of the total available renewable water resources. Aquastat, 2004.
17. *Consumption of Renewable Energy*: consumption of renewable energy as percentage of total energy consumption. IEA, 2001.
18. *Forest Area*: change in forest area of a country as pro mille content of world forest area in the period 1990–2005. FAO, 2005.
19. *Preservation of Biodiversity*: National Biodiversity Index. Global Biodiversity Outlook, 2001.
20. *Emission of Greenhouse Gases*: CO2 emission per capita. CDIAC, 2002.
21. *Ecological Footprint*: the ecological footprint in hectares per capita. WWF, Living Planet Report, 2001.
22. *International Cooperation*: participation in 14 international treaties and agreements with respect to human rights, nature and environment. HDR and ESI, 2004, 2005.

Appendix B

List of SSI scores for 150 countries

Rank	Country	SSI
1	Norway	7.0
2	Switzerland	6.9
3	Sweden	6.8
4	Finland	6.7
5	New Zealand	6.7
6	Austria	6.7
7	Iceland	6.6
8	Vietnam	6.4
9	Georgia	6.3
10	Japan	6.3
11	Uruguay	6.3
12	Netherlands	6.2
13	Canada	6.1
14	Bhutan	6.1
15	Denmark	6.1
16	Latvia	6.1
17	France	6.1
18	Paraguay	6.1
19	Korea, South	6.1
20	Nepal	6.1
21	Lithuania	6.1
22	Cuba	6.0
23	Costa Rica	6.0
24	Chile	6.0
25	Luxembourg	6.0
26	Sri Lanka	6.0
27	Germany	6.0
28	Cote d'Ivoire	5.9
29	Colombia	5.9
30	Mozambique	5.9
31	Portugal	5.9
32	Hungary	5.9
33	Gabon	5.9
34	Gambia	5.9
35	Congo	5.9
36	Slovak Republic	5.9
37	United Kingdom	5.9
38	Rwanda	5.9
39	Kenya	5.8
40	Italy	5.8
41	Albania	5.8
42	Bangladesh	5.8
43	Nicaragua	5.8
44	Benin	5.8
45	Spain	5.8
46	Ireland	5.8
47	Myanmar	5.8
48	Belgium	5.8
49	Turkey	5.8
50	Guyana	5.8
51	Indonesia	5.7
52	Brazil	5.7
53	Laos	5.7
54	Cambodia	5.7
55	Guinea	5.7
56	Malawi	5.7
57	El Salvador	5.7
58	Armenia	5.7
59	Tanzania	5.7
60	Togo	5.7
61	United States	5.7
62	Australia	5.7
63	Ghana	5.7
64	India	5.7
65	Panama	5.7
66	Central African Republic	5.6
67	Cameroon	5.6
68	Peru	5.6
69	Poland	5.6
70	Jamaica	5.6
71	Slovenia	5.6
72	Papua New Guinea	5.6

Appendix B (*continued*)

Appendix B (*continued*)

Rank	Country	SSI
73	Guatemala	5.6
74	Belarus	5.6
75	Ecuador	5.6
76	Moldova	5.6
77	Uganda	5.6
78	Guinea-Bissau	5.5
79	Croatia	5.5
80	Madagascar	5.5
81	Kyrgyz Republic	5.5
82	Romania	5.5
83	Senegal	5.5
84	Macedonia	5.5
85	Estonia	5.5
86	China	5.5
87	Greece	5.5
88	Russia	5.5
89	Ukraine	5.5
90	Bosnia-Herzegovina	5.4
91	Philippines	5.4
92	Liberia	5.4
93	Bulgaria	5.4
94	Dominican Republic	5.4
95	Bolivia	5.4
96	Czech Republic	5.4
97	Congo, Dem. Rep.	5.4
98	Haiti	5.4
99	Sierra Leone	5.3
100	Burkina Faso	5.3
101	Zambia	5.3
102	Argentina	5.3
103	Namibia	5.3
104	Cyprus	5.3
105	Ethiopia	5.3
106	Botswana	5.2
107	Zimbabwe	5.2
108	Mauritania	5.2
109	Trinidad and Tobago	5.2
110	Burundi	5.2
111	Mali	5.2
112	Nigeria	5.2
113	Azerbaijan	5.2
114	Lebanon	5.2
115	Serbia and Montenegro	5.2
116	Mexico	5.2
117	Malaysia	5.2
118	Chad	5.1
119	Thailand	5.1
120	Venezuela	5.1
121	Tunisia	5.1
122	Tajikistan	5.0
123	Honduras	5.0
124	Mongolia	5.0
125	Niger	5.0
126	Angola	4.9
127	Morocco	4.9
128	Israel	4.9
129	Kazakhstan	4.9
130	Taiwan	4.7
131	Algeria	4.7
132	Korea, North	4.7
133	South Africa	4.7
134	Sudan	4.7
135	Pakistan	4.6
136	Uzbekistan	4.5
137	Syria	4.5
138	Iran	4.5
139	Egypt	4.5
140	Jordan	4.4
141	Malta	4.2
142	Yemen	4.1
143	Iraq	4.0
144	Qatar	4.0
145	Libya	4.0
146	Kuwait	3.9
147	United Arab Emirates	3.9
148	Turkmenistan	3.8
149	Oman	3.7
150	Saudi Arabia	3.4

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