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CONTRIBUTIONS TO THE EVOLVING THEORY AND PRACTICE OF INDICATORS OF SUSTAINABILITY

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Introduction

The concept of sustainability has been difficult to define, both in diplomacy and in academia. This is an advantage in diplomacy, as it is always easier to agree on a text when each country can read into it what it wants to. Since sustainability really refers to a dynamic process rather than an end point (Dahl 1996a), the challenge of defining it is understandable. It is much easier to identify what is unsustainable that needs to be reduced or eliminated in order to maintain a sustainable balance over time.

In the absence of a precise definition of “sustainable development”, indicators of sustainable development or sustainability have become a primary tool for defining the parameters that need to be included in measuring sustainability. This paper focuses on the United Nations (UN) process, and follows the evolution of the theory and practice of sustainability indicators since Agenda 21, adopted at the Rio Earth Summit in 1992, which called for indicators of sustainable development to support decision-making and “to contribute to a self-regulating sustainability of integrated environment and development systems” (UN 1992, §40.4). It shares some insights into the intellectual history of the concept of indicators of sustainability within the UN framework, and in particular the struggle to address integration. It complements the separate paper in this volume on the events and processes through which this evolution proceeded (Dahl, Chapter 23, this volume).

My own interest in indicators had deep roots, starting with my research on complex biological systems like coral reefs (Dahl 1973), and continuing with indicators to define the conservation importance of islands (Dahl 1986, 1991). After helping to draft Agenda 21 in the UN Conference on Environment and Development (UNCED) secretariat, the United Nations Environment Programme (UNEP) assigned me the challenge to implement its Chapter 40 calling for information for decision-making, and I had to reflect deeply on the meaning of sustainable development (Dahl 1996b). My function was to try to provide some overall strategic vision to the challenge of measuring and guiding the world towards sustainability using indicators.

The starting point

The inclusion of a call for indicators of sustainable development in Chapter 40 of Agenda 21 launched a process within the United Nations system to develop such indicators, but without

any clear concept of what was involved. When governments at the early meetings of the Commission on Sustainable Development (CSD) were divided between those that saw the importance of measuring progress and those that expressed the fear that such indicators would be used to determine conditionality in development financing, it seemed important to launch a dialogue between scientists and policymakers about what such indicators might consist of and how they might be used, and within the scientific community about the design and content of such indicators (Bell and Morse, Chapter 12, this volume).

To start the process of implementation, UNEP commissioned an overview of environmental indicators: state of the art and perspectives led by Jan Bakkes of Rijksinstituut voor Volksgezondheid en Milieu (RIVM) (Netherlands) with Cambridge University which suggested a pressure/state/response (PSR) approach to interactions between the socio-economic system, the human population and the environment (UNEP/RIVM 1994).

The World Resources Institute (WRI) organised a Workshop on Environmental Indicators in Washington, DC, in December 1992, bringing together leading researchers from around the world to explore the state of the art in environmental indicators. One of the issues discussed was how to go beyond environmental indicators to indicators of sustainability, but it was felt that an index of sustainable development was not yet practical or advisable. The workshop and subsequent work contributed to a WRI report on environmental indicators (Hammond et al. 1995).

UNEP and the UN Statistical Office (UNSTAT) then convened a Consultative Expert Group Meeting on Environmental and Sustainable Development Indicators in Geneva on 6–8 December 1993. UNEP, UNSTAT and the International Development Research Centre (IDRC) all proposed conceptual models at the meeting. My opening working paper discussed some policy-oriented indices like Net Resource Product, Environmental Capital Index, Global, National and Individual Environmental Impact Indices, Net International Product, Industrial Efficiency Index, Social Equity Index, Intergenerational Equity Index, Human Welfare Index and a Capacity Building Index. It reviewed the challenges of developing policy-relevant indicators of sustainable development, and suggested vector indicators giving both speed and direction of progress towards (or away from) various sustainability targets (Dahl 1993). Peter Bartelmus of UNSTAT presented a draft Framework for Indicators of Sustainable Development (FISD) as a cross-reference between the internationally endorsed Framework for the Development of Environment Statistics (FDES) and the System of Environmental-Economic Accounting (SEEA) which represent the producer side of indicators, and the clusters of Agenda 21 of UNCED which reflected a key international use aspect (Bartelmus 1994).

Over time, a core group of indicator specialists formed a Consultative Group on Sustainable Development Indicators (CGSDI) that contributed creative thinking, participated in multiple processes and helped to maintain continuity and coherence between them. Some of the key members were:

Robert B. Wallace, Chairman of the CGSDI

Albert Adriaanse, a pioneer of environmental indicators and senior adviser at the Dutch Ministry of Environment (in the early years);

Jan Bakkes of RIVM in the Netherlands drawing on an important pool of expertise in his institute;

Peter Bartelmus and Reena Shah, of the UN Statistics Division;

Arthur Dahl, Coordinator of the UN System-wide Earthwatch, UNEP;

Gilberto Gallopin, Stockholm Environment Institute;

Allen Hammond, director of World Resources Institute's Resource and Environmental Information programme;

Peter Hardi, and later László Pintér, of the International Institute for Sustainable Development (IISD);
Jochen Jesinghaus of EUROSTAT and later the EU Joint Research Centre;
Donella Meadows, lead author of the 1972 report to the Club of Rome *The Limits to Growth* and updates, and adjunct professor at Dartmouth College;
Bedřich Moldan, first Minister of Environment in the Czech Republic, a vice president (and later president) of the Commission on Sustainable Development, on the Scientific Committee on Problems of the Environment (SCOPE), and Director of the Environment Center at Charles University in Prague;
John O'Connor, senior advisor at the World Bank;
Ismail Serageldin, World Bank vice president; and
Manuel Winograd, first at Ecological Systems Analysis Group, Bariloche, Argentina, and then at International Center for Tropical Agriculture (CIAT) Colombia.

CSD work programme on indicators

As the UN Division for Sustainable Development (DSD) worked with UN agencies to prepare an indicators programme for the Commission on Sustainable Development (CSD), it adopted a driving-force/state/response (DSR) framework, a modification of the pressure/state/response framework. A matrix of this framework across the chapters of Agenda 21 grouped in economic, social, environmental and institutional categories (often called the “four pillar model”), was used to organise indicators. There was no attempt at integration, simply trying to achieve the best coverage of indicators for issues across the framework. Ultimately a “blue book” of 134 indicators with methodologies was produced for trialling by governments (UN 1996; EUROSTAT 1997). The DSR framework was later expanded into a DPSIR framework, including both drivers and pressures, and adding impacts along with states and responses.

To support the evolution of the indicator programme, DSD organised a series of expert meetings to discuss progress at a technical level and to propose improvements, as well as a programme of country testing in a number of pilot countries (Dahl, Chapter 23, this volume). A number of complementary initiatives concerned approaches to aggregation and linkages, including by the World Resources Institute (WRI)/Wuppertal Institute Total Material Requirements, IISD highly aggregated indices, the World Bank on wealth measures and Genuine Savings, the International Union for Conservation of Nature (IUCN) Barometer of Sustainability, World Health Organization (WHO) aggregated health indicators, and UNSTAT integrated environmental and economic accounting (Bartelmus, Chapter 15, this volume). These still faced challenges of selection, scaling, weighting, aggregation and visualisation (UN 1997). In addition, many research projects on sustainable development indicators were funded by the European Union and other donors.

Drawing on the experience of 22 countries that tried out the DSR indicator framework during the testing phase, the Fifth Expert Group Meeting on Indicators of Sustainable Development, United Nations, New York, 1999, which I chaired in part, proposed the adoption of a theme/sub-theme framework and a smaller set of core indicators as being more relevant to policymakers (UN 1999a). These proposals were then elaborated for the workshop of testing countries in Barbados in December 1999 (UN 1999b). Social themes like equity, health, education, housing, security and population; environmental themes including atmosphere, land, oceans/seas/coasts, freshwater and biodiversity; economic themes for economic structure and consumption and production patterns; and institutional themes of framework and capacity, were

broken down into 38 sub-themes, each with one or more indicators, for a total of 58 core indicators to which countries could add those relevant to their specific situation. For institutional indicators, which had been the weakest dimension of the previous list, the Wuppertal Institute introduced a project to develop institutional indicators in the CSD framework. Agenda 21 was analysed regarding its institutional contents focusing on organisations, mechanisms and orientations, leading to suggestions for cardinal performance indicators. A number of existing CSD indicators were shown to be institutionally meaningful although specific for one or two of the sustainability dimensions (UN 1999b).

The second edition of the indicators handbook (UN 2001a) emphasised that “a successful framework should reflect the connections between dimensions, themes and sub-themes” and “the goals of sustainable development to advance social and institutional development, to maintain ecological integrity, and to ensure economic prosperity” (UN 2001a, p. 27). However, in practice, the result was still just a list of individual indicators integrated by the framework, rather than indicators of integration. DSD did explore the issues of linkages and aggregation during this process. It first commissioned an extensive review of existing examples of indicators with linkages and of indices based on aggregation, as well as geographic integration (Guinomet 1999). A commentary on this review noted the importance of distinguishing interlinkages of indicators and indicators of interlinkages (Spangenberg 1999). The latter are more difficult to develop, since they raise issues of dynamic interactions and decoupling. DSD summarised the key issues in a background paper for the Ninth CSD in 2001 (UN 2001b). The basic problem in most cases was the subjectivity of methods of aggregation.

Reena Shah of UNSTAT prepared a review of recent developments and activities (Shah 2004). DSD commissioned a paper on proposals for a way forward (Pintér et al. 2005). It reviewed recent trends in the development and implementation of SD indicators, discussed continuing interest in the development of aggregate indices, and in core sets of “headline indicators”, and looked at the emergence of goal-oriented indicators. Another theme was making better use of indicators in performance measurement (Almássy and Pintér, Chapter 13, this volume).

A third edition of the “blue book” was prepared in 2007, including 50 core indicators in a larger set of 96 indicators for sustainable development. It retained a themes and sub-themes approach with slightly modified 14 themes: Poverty, Governance, Health, Education, Demographics; Natural hazards, Atmosphere, Land, Oceans, seas and coasts, Freshwater, Biodiversity, Economic development, Global economic partnership, Consumption and production patterns; without categorisation into the four pillars of sustainable development. It reviewed a variety of indicator frameworks, including: Driving-force state-response frameworks, Issue- or theme-based frameworks, Capital frameworks, Accounting frameworks, Aggregated indicators, and other indicator approaches (UN 2007).

The research dimension

Alongside the intergovernmental process, the Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU, now the International Science Council) organised two SCOPE/UNEP projects on indicators of sustainable development (1994–1997) and (2004–2007). These projects brought together leading researchers in the field with those like Peter Bartelmus of the UN Statistical Division and myself for UNEP at the science-policy interface, to collect and assess the state of the art in indicators and stimulate further research. The projects became the research dimension of the CSD programme of work on indicators.

After its first meeting in Ghent between scientists and diplomats to address the political issues, the first SCOPE/UNEP project organised a Scientific Workshop on Indicators of Sustainable Development at the Wuppertal Institute in Germany on 15–17 November 1995 (Billharz and Moldan 1996; Dahl 1995). After an introduction to comprehensive approaches (Dahl 1997), over 50 leading researchers addressed topics such as environmental indicators of materials flows, spatial indicators from Geographic Information Systems (GIS), socio-economic indicators for sustainable development, frameworks and linkages, and the meaning of sustainable development for indicators, and made proposals for coherent indicator development and use. It was clear from the results that much progress had been made since the WRI workshop three years before, with many prominent new approaches. The SCOPE project concluded with the production of a book on *Sustainability Indicators* (Moldan et al. 1997).

When a UN Expert Meeting on Methodologies for Indicators of Sustainable Development was held in February 1996 to finalise the first “blue book”, it requested the SCOPE/UNEP project to explore linkages and to develop highly aggregated indicators based on different themes of sustainability.

One of the issues reviewed at the Fourth Expert Group Meeting on Indicators of Sustainable Development in 1997 was approaches to aggregation. It noted that

Several approaches to aggregation have been developed and are in different stages of application. Some examples include inter alia: (1) The World Bank work on Wealth Measures and Genuine Savings, (2) The IUCN Barometer of Sustainability, (3) UNDP’s Human Development Index, (4) UN work on integrated environmental and economic accounting, (5) The joint effort of the Wuppertal Institute and the WRI to develop among many flows an index of total material requirements (TMR). The WRI is also developing a strategic approach that would lead to a limited number of indices in the environmental field, (6) Work by EUROSTAT on pressure indices, (7) Global Environmental Change and Human Security Project (GECHS), and (8) Asian Development Bank’s Regional Technical Assistance Project on Environmental Indices.

(UN 1997, §59)

The International Institute for Sustainable Development (IISD) organised “Beyond Delusion: Science and Policy Dialogue on Designing Effective Indicators of Sustainable Development” on 6–9 May 1999 in San Jose, Costa Rica, with 40 participants (www.iisd.ca/crs/scipol/ [accessed 12 December 2016] and summary at IISD 1999). It supported the dashboard approach, and debated the advantages of a single Sustainable Development Index or a set of sub-indices. It agreed on the need to present indicators in clusters and to embed them in decision-making processes. The greatest challenges were:

the difficulty of grappling with a difficult concept; the use of the same indicators for a variety of levels; the importance of accounting for everyone’s interests; the need for indicators that reflect specific contextual situations without losing comparability; the difficulty of determining how much time is left before irreversible damage occurs; the inequality of nations on the global level; the need to convince decision-makers to think long term; the need to ensure indicators make an impact on decisions; and the use of indicators to address changing needs and consumption patterns.

(IISD 1999, p. 5)

The science of indicators advanced so rapidly that SCOPE initiated a second project, the SCOPE/UNEP/IHDP/EEA Assessment of Sustainability Indicators (ASI) project (2003–2007) with the International Human Dimensions of Global Environmental Change Programme (IHDP) and the European Environment Agency (EEA), to make a scientific assessment of progress and to define outstanding challenges, paralleling the preparation by the UN of the third edition of its guidelines and methodologies. The central activity was the ASI Workshop on 10–14 May 2004 in Prague, Czech Republic. Based on over 60 working papers presenting many indicator approaches, and three cross-cutting working groups on meeting conceptual challenges, identifying methodological challenges and ensuring policy relevance, the results were written up in a comprehensive volume *Sustainability Indicators: A Scientific Assessment* with 23 chapters by groups of leading experts (Hak et al. 2007). The introductory chapter provided an overview of the issues still faced, starting with the definition of sustainability itself. It identified the multiple ways in which indicators could be made policy relevant, and the need for many approaches to respond to the diversity of situations around the world, and to meet the needs of different users. It highlighted the need to consider the ethical component of sustainability in designing indicator programmes. It also commented and compared selected indicators, indices and indicator programmes (Moldan and Dahl 2007). The conceptual challenges included going from pillars to linkages to systems; expanding temporal and spacial scales; finding planetary limits; exploring vulnerability, resilience and irreversibility; and adding meaning with reference values, trends and targets. They also concerned issues of process and universality, such as cultural diversity, comparing countries and closing in on equity (Karlsson et al. 2007; Reijnders, Chapter 20, this volume). One important issue flagged in the book is the need for better approaches to the integration of many indicators into more comprehensive assessments of sustainability (Dahl 2007). This issue has emerged again in the design of the UN 2030 Agenda and its Sustainable Development Goals, targets and indicators (UN 2015). The ASI project provided a definitive review of the science of sustainability indicators as the CSD programme of work was coming to completion.

Efforts at integration

While governments refused to consider indicators that might be used for comparisons between countries, the scientific, academic and civil society communities have had no such qualms, leading to efforts to develop composite indices that could combine many indicators into an integrated measure to rank countries and motivate improvements. The review by SCOPE is reasonably comprehensive (Hak et al. 2007, especially Moldan and Dahl 2007). Some of the most popular indices, such as the Ecological Footprint (Wackernagel et al., Chapters 16 and 33, this volume) or the Worldwide Fund for Nature (WWF) Living Planet Index, are designed to be communications tools rather than assessments of sustainability in all its complexity, and are successful in their intended purpose. The examples that follow have been selected to illustrate some of the challenges with composite indices that include many dimensions of sustainability.

Environmental Vulnerability Index (EVI)

The Barbados Conference of Small Island Developing States (1994) called for the development of a vulnerability index or indices for Small Island Developing States (SIDS). The UN followed up by organising an ad hoc expert group on vulnerability indices in New York on 15–16 December 1997. While Lino Briguglio (1995) had pioneered work on the economic vulnerability of islands, I noted at the meeting that little had been done to address the environmental

vulnerability of islands apart from the economic impact of natural disasters. The South Pacific Applied Geoscience Commission (SOPAC) in Fiji decided to take up the challenge of developing indicators of environmental vulnerability, and in 1999 invited me to contribute to their conceptualisation. For the first time, each indicator was related to a scientifically designed end point of sustainability or resilience, rather than just relative measures comparing countries, none of which might have been sustainable. The result was a set of 50 indicators for various dimensions of environmental vulnerability particularly relevant to islands but appropriate for all countries. To extend this work to the world level, I co-organised and participated in the SOPAC/ UNEP Global Environmental Vulnerability Indicators Meeting in Geneva in 2001 (Kaly et al. 2001) which made this work available to a wider audience. The resulting Environmental Vulnerability Index (EVI) was launched at the SIDS preparatory session of the UN Commission on Sustainable Development (CSD) in New York in 2004. The work was finalised at an EVI Think Tank II at SOPAC, Suva, Fiji, in 2004 (Alder et al. 2004), and a graphic presentation showing a country profile for environmental vulnerability with the 50 indicators was developed. I was then part of the SOPAC delegation to present the EVI calculated for a hundred countries in a side event at the Mauritius International Meeting on further implementation of the Programme of Action for Small Island Developing States in January 2005. The effectiveness of the EVI was demonstrated when I was given 3 minutes to explain it to the Irish Minister of Development Cooperation, who was to speak for the European Union at the side event, using Ireland's own country profile. He understood immediately, seized its significance and spoke enthusiastically about its importance at the side event. Unfortunately, SOPAC had no mandate to take the work further at the global level, so it has not been updated since 2005.

Environmental Sustainability Index (ESI) and Environmental Performance Index (EPI)

The Environmental Sustainability Index was an academic initiative of the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network (CIESIN) at Columbia University, in collaboration with the World Economic Forum (WEF) and the Joint Research Centre of the European Commission. It was produced in a pilot version in 2000 and revised in 2001, 2002 and 2005. The 2002 version, produced for the Global Leaders of Tomorrow Environment Task Force, World Economic Forum Annual Meeting in 2002, aimed to measure overall progress of 142 countries towards environmental sustainability using 20 indicators each combining two to eight variables, for a total of 68 underlying data sets. It tracked relative success in five core components: Environmental Systems, Reducing Stresses, Reducing Human Vulnerability, Social and Institutional Capacity, and Global Stewardship (Esty et al. 2002). As with all such aggregated indicators, it faced challenges of the selection of themes to be measured and the aggregation methodology, in this case equal weighting of the themes with relative rankings from worst to best in the combined index. In the initial versions, there were strong criticisms of the rankings, which seemed to have a bias towards developed countries. I attended a Workshop on the Environmental Sustainability Index at the World Economic Forum in Geneva in 2001, and the World Economic Forum asked me to advise them whether they should continue to collaborate in the ESI. I was then brought in as advisor to the World Economic Forum and Yale University in the redesign of the ESI for 2005 where we made major improvements and also qualified the interpretation of the rankings (Esty et al. 2005). However, the ESI still ranked countries by their performance relative to other countries, so even if everyone was doing badly, some would still rank highly.

At the same time, we developed the concept for a new Environmental Performance Index (EPI) first issued as a pilot in 2006 (Esty et al. 2006) and updated every two years (Esty and Emerson, Chapter 5, this volume). Drawing on the experience with the Environmental Vulnerability Index (EVI), the indicators making up the EPI were all related to scientifically determined targets of sustainable environmental performance, so that a high score would really show that a country was approaching environmental sustainability. The 2016 EPI ranks 180 countries on how well they perform in two broad policy areas: protection of human health from environmental harm, and protection of ecosystems, scoring country performance in nine issue areas comprised of 20 indicators (Hsu et al. 2016). There are still issues of the selection of measures and their weighting. While the comparisons of country performance in a particular year can be very policy relevant, adding or revising a few indicators can produce wide variations in the rankings, as illustrated by the significant shifts between the 2014 and 2016 EPIs, which can raise issues of credibility (Hsu et al. 2014, 2016; Conrad and Cassar, Chapter 19, this volume). One point with respect to these indices that rank countries is that their greatest value is in peer comparisons between countries in similar situations and stages of development, where the indicators can signal best practices.

CGSDI

Another initiative to address the intellectual challenges in measuring sustainability was the creation of the Consultative Group on Sustainable Development Indicators in 1996 as a kind of think tank about the process. We were a small group, initially of eight, supported by the Wallace Global Fund and with a secretariat at IISD, whose mission was to promote cooperation, better coordination and strategising among key individuals and institutions working on developing and using sustainable development indicators. The path we followed suggests some of the continuing conceptual difficulties with integrating sustainability indicators.

Our first focus was on developing highly aggregated measures of sustainable development. We started working on a sustainability index, which proved conceptually too challenging, before shifting the emphasis from one index to a set of highly aggregated indices and exploring an appropriate framework for defining clusters to integrate indicators. We discussed new aggregate indices and ways to normalise indicators to show sustainability levels. We identified a need for welfare-related indicators. Our tasks included defining a set of new indices, finding a powerful index to mobilise decision-makers, finding a methodology to overcome gaps in existing evaluations and making comparisons to desirable or targeted levels (UN 1997).

After its first year of work, the CGSDI suggested that highly aggregated indices could be arranged in nested arrays with ever higher levels of aggregation within internally consistent units: nature/environment in physical units, economy in monetary units, social and institutional dimensions in social science units, and individual welfare in demographic, percent population or per capita units. Each parameter should include state/stock, flow/trend, driving forces and responses, and a direction, target or trajectory towards sustainability. To make this complex framework accessible to decision-makers, we discussed if the four components could be arranged as compass directions, but also could be related along another axis to the ultimate goals of human satisfaction and biosphere sustainability. Simple colour-coded graphic presentations could provide warning signals of unsustainable trends for decision-makers and the public. Models could be developed to show underlying linkages in human and natural systems (summarised in UN 1998, §21–23).

With some further work, a main product of the group shifted to the Dashboard of Sustainability, created by Jochen Jesinghaus to present complex indicator data sets in an easy-to-understand

graphic form, while making it possible to burrow down for the details for those who were interested. It could be used for a variety of data sets (Jesinghaus collected over 400), and could allow users to try different weightings of indicators and to see their effect on the final indices. This showed how composite indices are sensitive to underlying assumptions and choices of indicators, and can even produce results that are counter-intuitive depending on how measures are selected and interpreted.

Beyond the tool to make the indicators understandable, much of the CGSDI discussion was about the content, selecting the most appropriate indicators for all the significant dimensions of sustainability, such as whether GDP should be included or replaced by a better indicator, and avoiding hidden underlying assumptions. We also debated whether statistical analyses would add anything. One continuing problem was the adequacy of available data sets to cover all the essential components of sustainability assessment, as well as the bias introduced by data being most available in industrialised countries and emphasising their definition of desirable development.

The CGSDI also faced the challenge of deciding who should be the target audience: policy-makers to influence short-term decisions with marginal effects, system planners to demonstrate the need for a fundamental transformation of the system or even the general public. What would be required for a sustainable development index to be quoted in the media and widely used like GDP? How do you go beyond a purely intellectual exercise to make a difference? Despite various attempts, we never really found the answers to these questions.

An ultimate dream of some of us in the CGSDI was to achieve dynamic systems modelling of the whole sustainability challenge, beyond what the World 3 model was able to for the research on *The Limits to Growth* (Meadows et al. 1972, 1992, 2004). By placing all the indicators into a coherent dynamic framework, since they are all interdependent, it should be possible to derive secondary indicators of processes and rates of change, interactions, and positive and negative feedbacks, that would say much more about the sustainability of the whole system.

Exploring new directions

The focus of most indicators of sustainable development has been at the technical level of planetary systems and resources, components of the economic system, and collective social impacts and behaviours. Yet, apart from the institutional aspects, it is individual human beings who decide to be more or less sustainable in their lifestyles, consumption patterns and political choices at least in democratic systems. Even at the highest levels of policy, decisions are usually based on the values and ideological perspectives of political leaders. Education for sustainable development is recognised as an important dimension of any programme for sustainability, but indicators of the impact of such education on individuals are largely lacking, especially with respect to values and behaviour (Dahl 2012b). Exploring the role of values and ethics in achieving sustainability, and developing indicators of the state and trends in values in individuals and populations, and of the impact of efforts in education and public information on these values, would have considerable potential for leveraging change.

With colleagues, I helped to design and lead a research programme in 2008–2011 on values-based education for sustainable development, with a focus on finding indicators of the ethical dimension that could be used to assess the success of educational efforts. With financial support from the European Union Seventh Framework Programme, research teams at the University of Brighton (UK) and Charles University in Prague collaborated with several civil society organisations, including the Earth Charter Initiative, the Alliance of Religions and Conservation, EBBF (Ethical Business Building the Future) and The Peoples' Theatre (Germany) to crystallise their own values and to identify how they were expressed in their own context in ways that

could be objectively measured to generate indicators. Pilot projects looked at indigenous school children in Mexico, a university programme in sustainability, a Red Cross project with former child soldiers in Sierra Leone, a cosmetics company in Italy, a youth theatre project in Germany, inner city Moslem women in London, and as a control a financial services company in Luxembourg. The results were launched at an international conference at the University of Brighton in December 2010 (<https://iefworld.org/conf14>). The resulting indicator methodologies have now been applied to the youth programmes of the International Federation of the Red Cross and Red Crescent Societies, with the Earth Charter Initiative educational programmes and in toolkits for use in secondary education (Dahl et al. 2014a, b, c), among others. Descriptions of various dimensions of the research have been published (Podger et al. 2010; Dahl 2011; Dahl 2013; Burford et al. 2013; Burford et al. 2015; Podger et al. 2015; Ribeiro et al. 2016).

In addition to the research coming directly out of the programme, various dimensions of values in education have been explored with reference to individual motivation (Dahl 2012a, 2012d, 2014a; Howell 2013), individual accountability (Dahl 2015b), sustainable consumption and production (Dahl 2012c), ethics (Dahl 2015a) and higher education (Dahl 2014c), as well as a more general framework for values-based indicators (Dahl 2013) and a recent update (Dahl 2016a).

A related approach concerns indicators of happiness and well-being, which could be seen as an outcome of greater sustainability. The concept was pioneered by the Government of Bhutan, which has developed and refined its Gross National Happiness index as a more culturally appropriate replacement for GDP including a values dimension (Ura et al. 2012). The concept has gradually been taken up by other countries and was presented by Bhutan at the United Nations in 2012, inspiring among other things the *World Happiness Report* (Helliwell et al. 2012, 2013, 2016; Sachs et al. 2016). In one of the papers in the 2013 report, co-author Jeffrey Sachs particularly highlights the happiness that comes from leading a virtuous life (Sachs 2013). This has led to a proposal for a whole set of indicators for individual well-being to support the transition to sustainability (Dahl 2014b).

There is another significance to this new research into the ethical or values dimension of sustainability. Effective large-scale social transformation depends on social cohesion, and failures in social cohesion can lead to chaos (Turchin 2010) which will regress rather than advance sustainability. A recent analysis by Peter Turchin of the factors that enabled more complex and large-scale levels of social organisation and civilisation to emerge suggests that an ethical transformation mediated by religion tipped the balance towards altruism and enabled multi-cultural and multi-ethnic societies to flourish over large areas (Turchin 2016). The transition to sustainability requires a strongly altruistic focus on the protection of the environment and the well-being of future generations. All of the efforts to put in place the technical requirements for sustainable development will fail if the political, social and economic actors all give priority to their selfish personal, national or corporate interests. Developing indicators of the ethical content or orientation of the different social actors will be an important guide to the success or failure of programmes for sustainability.

The UN 2030 Agenda

The latest framework for indicators of sustainability is the United Nations 2030 Agenda and its 17 Sustainable Development Goals (SDGs), with 169 targets and over 240 indicators (UN 2015; IAEG-SDGs 2016). Space does not permit more than a short mention of the new challenges and opportunities in the development of the SDG indicators.

While the early discussion of sustainable development indicators recognised the need for indicators of planetary sustainability with reference to global resources and life-support systems,

it was only when researchers began to identify and quantify planetary boundaries (Rockström et al. 2009; Wijkman and Rockström 2012; Steffen et al. 2015) that such indicators became possible. The 2030 Agenda responds to this recognition that we are at or beyond sustainable planetary limits and must make a fundamental and rapid transition to sustainability. The SDGs are the first updated and globally accepted definition of the content and meaning of sustainable development since Agenda 21. The targets are global, and need to be translated into corresponding efforts at the national level, much as the CSD indicators were developed two decades ago.

There was already a wide debate as the SDG indicators were being developed. The Inter-Agency and Expert Group on Sustainable Development Goal indicators, advising the UN Statistical Commission, revised and updated its proposals several times before agreeing on a first workable set of indicators (IAEG-SDGs 2016). Meanwhile, the Sustainable Development Solutions Network (SDSN), taking a more scientific perspective as opposed to that of the statisticians, made its own series of proposals for indicators for each of the SDG targets (SDSN 2015). A critique by the International Council for Science (ICSU) and the International Social Science Council (ISSC) raised questions about the drafting of the targets that often made it difficult to measure and assess progress properly (ICSU and ISSC 2015). Groups of researchers are also contributing to the debate (Pintér et al. 2015, Sachs et al. 2016), and this will certainly continue as the indicators are developed and refined between now and 2030.

To illustrate the complexity of the challenge, my comparison of the indicators proposed for SDG 14 on oceans, between those proposed by the Statistical Commission, those of the SDSN from a science perspective, and those of the Global Oceans Commission as seen from the Law of the Sea perspective, showed little overlap between the different sets of indicators (Dahl 2015c). Another study has compared the UN approach and a values-based approach for one educational target (4.7) to show that there are important gaps in the traditional approach and to demonstrate the complementarity of values-based locally relevant indicators, requiring a conceptual shift from education for transmission to education for transformation (Burford et al. 2016).

While the 2030 Agenda and its SDGs are explicitly an integrated whole, there is still much to be done to make that integration a practical reality, a challenge that has been with indicators programmes since the beginning. Some targets would seem to be conflicting, if not incompatible, such as those for continuing economic growth and environmental protection. The SDGs themselves call for new indicators, for example alternative indicators to GDP for the economy. One integrated approach is material flow analysis, and the International Resource Panel has recently prepared a first global data set of material flow indicators (UNEP 2016). The International Council for Science has launched a project to explore SDG integration in more detail (Nilsson et al. 2016a, Nilsson et al. 2016b; ICSU 2017).

While the 2030 Agenda is supposed to be an agenda of, by and for the people, it has inevitably been largely a top-down UN process, even with widespread stakeholder participation. The SDGs are global goals, and it is governments that are expected to develop national implementation and to report on progress. Yet governments by themselves cannot achieve sustainability without the cooperation of business, civil society and the public in general. There is thus enormous scope for other actors to take on the SDGs as their own and to work for their implementation, producing their own indicators of progress. It is even possible to explore the implementation of the SDGs as communities and individuals (IEF 2016) and to create SDGs that individuals can take on as their own goals (Dahl 2016b). This would obviously lead to indicators for individual behaviour and achievement.

The SDGs provide a new mapping of the key characteristics of a sustainable world system with a detail never achieved before. Perhaps it will now be possible to place all the indicators into an integrated systems framework (Capra and Luisi 2014), and to determine its emergent

properties with a new set of indicators of integration, finally realising our dream in the CGSDI 20 years ago.

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