Key Approaches for Sustainable Development Measurement

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Abstract. *It is emphasized in the article that it's impossible to measure such a complex concept as sustainable development in a narrow mathematical way, certainly because the value for each factor differs. It states that sustainable development should be: economically viable, ecologically sustainable and socially desirable. An indicator quantifies and simplifies phenomena and helps to understand complex realities. Indicators can be divided into different categories and groups according to the specific organization and methodology used.*

Keywords: *sustainable development, sustainable development measurement, indicators, indices.*

1 Introduction

Sustainable development is characterized by a complex set of interrelated factors such as poverty, health, environment, welfare, food, education, human rights, social stability, etc. It's impossible to measure such a complex concept in a narrow mathematical way, certainly because the value for each factor differs for individual to individual, from issue to issue and from place to place.

For as far as possible, one can have an idea about the quantity of sustainable development by putting the most important factors in an indicator and calculating a 'sustainable development'-index.

Indicators are fit in models to help to understand the complexity of reality. Therefore, models are always a simplification of reality, combining the essential elements and the relationships between them.

From an operational point of view, sustainable development should be:

– Economically viable: paying for itself, with costs not exceeding income.

– Ecologically sustainable: maintaining long-term viability of ecosystems.

– Socially desirable: fulfilling people's cultural, material and spiritual needs in equitable ways.

Sustainable development can only be achieved by fulfilling the economic, environmental and social objectives. Figure 1 provides a simple representation of the basic components of sustainable development. It shows that its ultimate aims to maximise the (black) area where economic, social and environmental agendas and targets coincide with each other.

The aim of the article is to explain the ways of sustainable development measurement.

2 Methodology

This research analyzes different approaches to measure such a complex phenomenon as

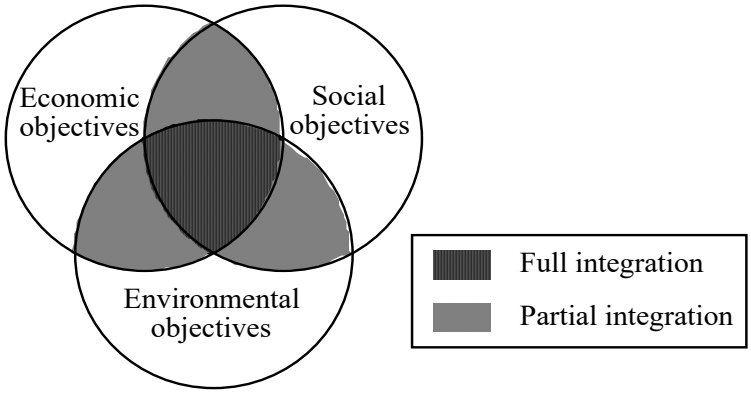

Figure 1 Sustainable development is the zone where social, economic and environmental objectives are fully integrated

sustainable development. To implement this aim, different methods of research were used. They include synthesis, abstraction, generalization, induction, deduction, explanation, classification. Genera-lization was used to provide common characteristics for different types of sustainable development measurement. Induction was applied to get from individual facts (for instance, elements of different indicators) to general ones (including their whole structure).

3 Results

An indicator quantifies and simplifies phenomena and helps to understand complex realities. An indicator provides information about the changes in a system. Whether the indicator is useful, depends on the particular context where the indicator is used.

According to Chapter 40 of Agenda 21, "indicators of sustainable development need to be developed to provide solid basis for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems". The following are essential features of indicators:

Indicators must be relevant, serving their purpose, capturing and measuring the essence of the issue.

They must be understandable for all members of the target group. Complex indicators developed by academics to measure complex processes or situations loose their relevance unless simplified to be understandable for everyone.

Their conception must be well founded and easy to interpret.

They should be easily adaptable to new developments, thus responsive.

They need to show the link between economic, social, environmental and institutional aspects of society.

They should embrace a long-and wide-range view and show trends over time.

Indicators should be global.

They must be reliable (based on reliable data) although not necessarily precise.

Data should be available at a reasonable cost-benefit ratio, adequately documented, of known quality, and regularly updated. They must provide information in a timely fashion, so as to be able to prevent or solve problems in due time.

The three last features could be summarized in terms of 'feasibility': are they appropriately measurable in a time- and cost-effective way? They should also have a threshold or reference value against which progress could be measured.

(Atkinson et al., 1997; Hardi and Zdan, 1997; Hart, 1996; Mitchell, 1996; OECD, 1997; UN, 1996)

According to OECD, indicators can be divided into six different categories:

– Social indicators
– Environmental health indicators
– Economic indicators
– Energy indicators
– Housing indicators
– Sustainability indicators (OECD, 1997)

Indicators can also be divided into single and composite indicators. Single indicators refer to one variable and can be calculated relatively simple. Composite indicators are environmental indicators, which are combined or aggregated to produce a single figure or index (EPA-NSW, 2001). A set of composite indicators simplifies complex phenomena in a set of commonly understood measures (EPA-NSW, 2001).

The relationship between the essential constituents of sustainable development can be modelled. The Pressure-State-Response-model (PSR-model) was developed in 1994 by the Organisation for Economic Co-operation and Development (OECD). This model interrelates human activity with the state of the environment.

The PSR-framework (Figure 2) is based on a concept of causality that implies that human activities exert pressures on the environment and change its quality and the quantity of natural resources. Society responds to these changes by establishing environmental, general economic and sectoral policies. The responses form a feedback loop to the pressures caused by human activities.

Table 1 Examples of single and composite indicators in three different sub area's

Sub area	Single indicator	Composite indicator
Economy	Unemployment ratio	Gross National Product
Environment	NOx-emissions	Total acid emissions Global Warming Potential Ecological Footprint
Social	Literacy levels	Index of sustainable economic welfare

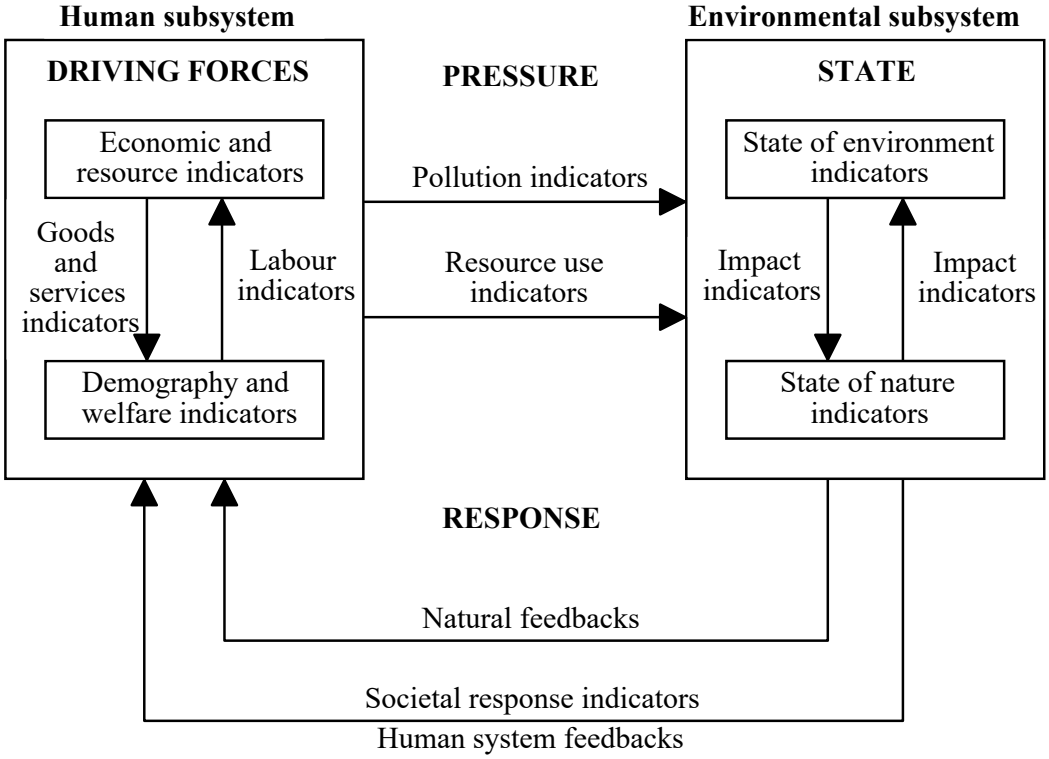

Figure 2 The conceptual framework of the PSR-model (after UNEP and DPCSD, 1995)

In a wider sense, these steps form part of an environmental policy cycle that includes problem perception, policy formulation, monitoring and policy evaluation (Guven, 2001).

An interesting aspect of the model is that each of the individual relations (the arrows in Figure 2) can be characterized by a quantitative measure. For the labour indicators, this might be the number of people at work. Policy responses are characterized by waste or energy plans etc. These quantitive measures are called indicators.

The PSR framework distinguishes three broad types of indicators: indicators of environmental pressures that describe pressures from human activities exerted on the environment, including the quality and quantity of natural resources; indicators of environmental conditions that relate to the quality of the environment and the quality and quantity of natural resources; and indicators of societal responses that are measurements which show the extent to which society is responding to environmental changes and concerns (Guven, 2001). The PSR-framework divides the indicators into 14 different issues or themes.

In April 1995, during its third session, the Commission on Sustainable Development (CSD) approved a work programme on indicators of sustainable development. The work programme included a list of 134 indicators organized in the Driving forces-State-Response-model (DSR-model). In this model, Driving Force indicators represent human activities, processes and patterns that impact on sustainable development, State indicators indicate the "state" of sustainable development, and response indicators indicate policy options and other responses to changes in the state of sustainable development. The DSR-framework allowed to develop indicators belonging to the four different categories of Agenda 21: the social category, the economical category, the environmental category and the institutional category (Guven, 2001).

The European Environmental Agency (EEA) developed a conceptual framework known as the Driving forces-Pressure-State-Impact-Response assessment framework. Particularly useful for policy-makers, this DPSIR-model builds on the existing PSR-model and offers a basis for analysing the inter-related factors that impact on the environment (EEA, 1999).

Driving forces are the social, demographic and economic developments in societies and the corresponding changes in life styles and overall levels of consumption and production patterns. The major driving forces are population growth and changes in needs and activities of individuals. The driving forces provoke changes in overall levels of production and consumption and thereby exert pressure on the environment. The exerted pressure may manifest itself in various ways, e.g. the excessive use of natural resources,

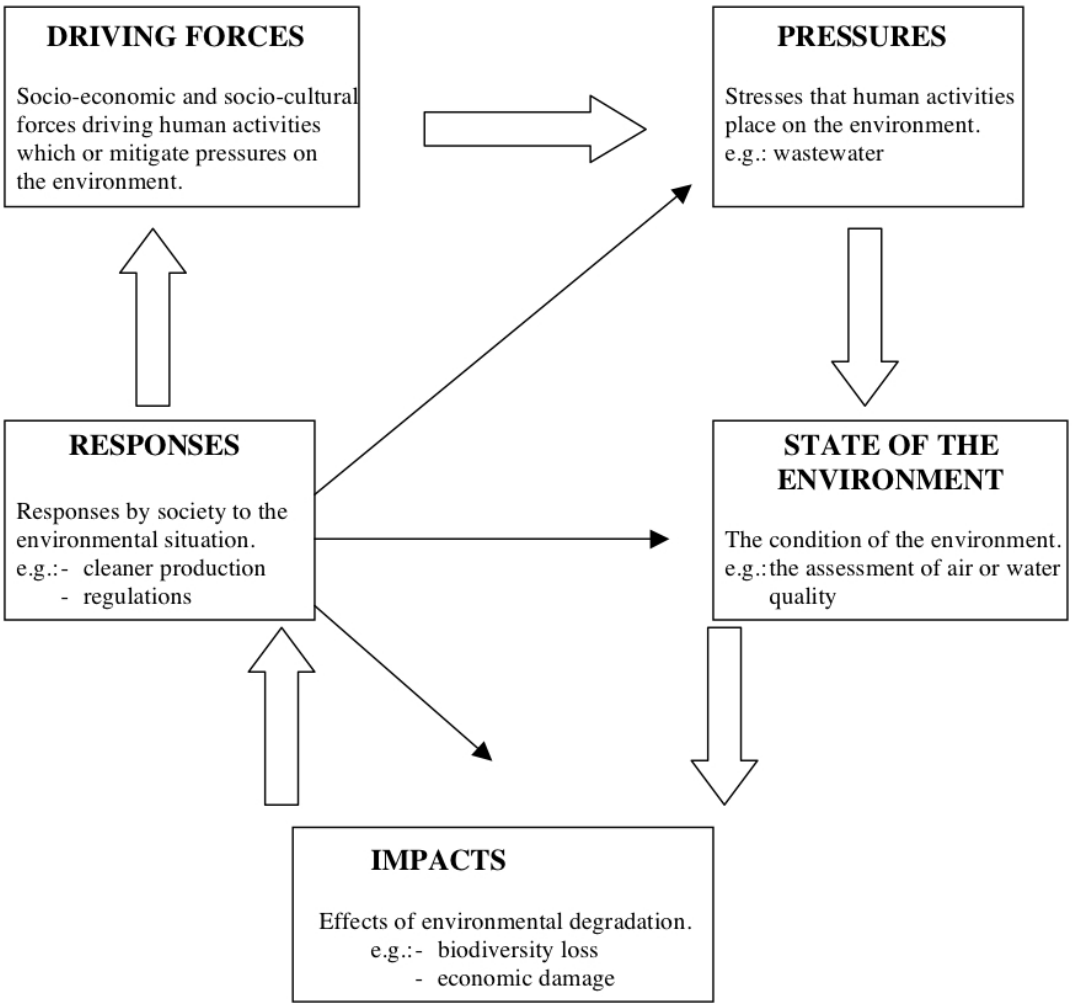

Figure 3 DPSEEA-model

changes in land use and emissions of chemicals, waste, radiation and noise to air, water and land (Guven, 2001).

The Pressure component therefore gives information on emissions, application of chemical and biological agents, and the use of land and other resources. The pressures exerted by society's patterns of production and consumption are subsequently transformed in a variety of natural processes that may result in changes in the state of the environment (Guven, 2001). For example, more vehicles result in an increase of carbon dioxide emissions into the atmosphere.

The State component gives information on the level, quality and/or quantity of physical phenomena, biological phenomena and chemical phenomena in a given area at a given point in time. Changes in the state of the environment may have environmental and economic impacts on ecosystems and eventually on human health and the economic and social welfare of a society (Guven, 2001). For example, an increase of the amount of carbon dioxide in the atmosphere result into global climate changes.

The Impact component presents data on the impact of the change of the state of the environment on the foregoing factors (Guven, 2001). For example, global climate changes will cause biodiversity loss, fluctuating sea levels, desertification.

Response refers to the reaction of the government, institutions, groups of people and individuals to undesired impacts on the environment in order to prevent, mitigate, ameliorate or adapt to changes in the environment. For example, responses may seek to change and/or redirect prevailing trends in consumption and production of goods and services, improve the monitoring and control of pollutants or to develop cleaner technologies (Guven, 2001).

The Driving forces-Pressures-State-Exposure-Effects-Actions-model (DPSEEA-model) builds further on the DPSR-model. It has been developed to deal with the specific elements of environment-health problems in a decision-making context.

The 'driving forces'-component refers to the factors that motivate and push the environmental processes involved. Of these, possibly the most important is population growth; others include technological development, economic development and policy intervention (WHO, 1999).

The driving forces within the DPSEEA model result in the generation of Pressures on the environment. These are normally expressed through human occupation or use of the environment and may be generated by all sectors of economic activity, including mining and quarrying, energy production, manufacturing, service industries, transport, tourism, agriculture and forestry. In each case, pressures arise at all stages in the supply chain – from initial resource extraction, through processing and distribution, to final consumption and waste release (WHO, 1999).

In response to these pressures, the State of the environment is often modified. The changes involved may be complex and far-reaching, affecting almost all aspects of the environment and all environmental media. They are expressed, therefore, in terms of the frequency or magnitude of natural hazards, the availability and quality of natural resources and the levels of environmental pollution. These changes in the state of the environment also operate at markedly different geographic scales. Many changes are intense and localized and often concentrated close to the source of the pressure (e.g. habitat loss, urban air pollution, contamination of local water supplies). Many others are more widespread, contributing to regional and global environmental change (e.g. desertification, marine pollution, climate change). Because of the complex interactions that characterize the environment, almost all these changes have far-reaching secondary effects (WHO, 1999).

Exposure refers to the intersection between people and the hazards of the environment. In the case of environmental pollution, exposure can occur in different ways (by inhalation, ingestion or dermal absorption) and may involve a wide range of different organs. 'External exposure' refers to the quantity of the pollutant at the interface between the recipient and the environment. It is often measured either using some form of personal monitor (e.g. passive sampling tubes for air pollution) or by modeling techniques (e.g. based upon knowledge of concentrations in the ambient environment). The amount of a pollutant that is absorbed is often termed the 'absorbed dose' and may be dependent on the duration and intensity of the exposure (WHO, 1999).

Exposure to environmental hazards, in turn, leads to a wide range of health effects. These may vary in type, intensity and magnitude depending upon the type of hazard to which people have been exposed, the level of exposure and the number of people involved. Important are the effect that occur at concentrations and exposure conditions that prevail in the environment. The earliest, and least intense, effects are sub-clinical, merely involving some reduction in function or some loss of wellbeing. More intense effects may take the form of illness or morbidity. Under the most extreme conditions, the result is death (WHO, 1999).

Action refers to the environmental, social and economic measures at international, national and sectoral level to control the consequences.

4 Conclusion

Measuring sustainable development is important for science and policy aspects. Science for sustainable development necessitates quantification. It's difficult to quantify a complex concept like sustainable development in a narrow mathematical sense, particularly when each factor's value varies. It notes that sustainable development should be economically viable, environmentally stable, and socially beneficial. An indicator is a tool that quantifies and simplifies phenomena and aids in the comprehension of complex situations. Depending on the organization and methods used, indicators may be divided into various categories and classes.

References

Atkinson G., Dubourg R., Hamilton K., Munasiighe M., Pearce D. and Young C. (1997). Measuring Sustainable Development: Macroeconomics and the Environment, Edward Elgar, Cheltenham, p. 252.

Doom R., De Jonge W., Van Assche J., Mazijn B. (2001a). Synthese PODO Onderzoek naar de Mogelijkheid en Beperkingen van het Concept Milieugebruiksruimte, The Environmental Utilisation Space, Capabilities and Limitations of a Concept, Centrum voor Duurzame Ontwikkeling. URL: http://www.belspo.be/belspo/home/publ/pub_ostc/HL/rHL12s_en.pdf.

Doom R., De Jonge W., Van Assche J., Mazijn B. (2001b). Onderzoek naar de Mogelijkheid en Beperkingen van het Concept Milieugebruiksruimte, Eindrapport 2001, Onderzoek binnen het Programma 'Hefbomen voor een beleid gericht op duurzame ontwikkeling', Inleiding, Belang van de studie in het kader van het programma 'Hefbomen voor een beleid gericht op duurzame ontwikkeling'. URL: http://www.belspo.be/belspo/home/publ/pub_ostc/HL/rHL12_nl.pdf.

EPA-NSW (2001). Composite indicators for sustainable development, The Future of NSW SoE Reporting, Part 2: A New Approach to State of the Environment Reporting, Section 7: Composite Indicators. URL: http://www.epa.nsw.gov.au/soe/issues/4_3.htm#0_4_3_2_0_0_0.

European Environmental Agency, EEA (1999). How we reason. URL: http://www.eea.europa.eu/documents/brochure/brochure_reason.html.

Guven S. (2001). International Frameworks for the Development of Environment Statistics and Indicators. URL: http://www.unescap.org/Stat/envstat/stwes-015.pdf#search=%22international%20frameworks%20development%20environmental%20statistics%20indicators%22.

Hardi P. and Zdan T.J. (1997). Assessing Sustainable Development, International Institute for Sustainable Development, Winnipeg.

Hart M. (1996). Sustainable Community Indicators. A Trainers' Workshop. Hart Environmental Data, Massachusetts.

Mitchell G. (1996). Problems and Fundamentals of Sustainable Development Indicators. *Sustainable Development*, 4, 1–11.

Organization for Economic Co-operation and Development, OECD (1997). Environmental Indicators for Agriculture.

Naidoo, R., & Fisher, B. (2020). Reset sustainable development goals for a pandemic world.

New Economics Foundation (2006). The Happy Planet Index, An Index of Human Well-being and Environmental Impact. URL: http://www.neweconomics.org/gen/uploads/dl44k145g5scuy453044gqbu11072006194758.pdf.

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockström, J. (2019). Six transformations to achieve the sustainable development goals. *Nature Sustainability*, 2(9), 805–814.

Schroeder, P., Anggraeni, K., & Weber, U. (2019). The relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology*, *23*(1), 77–95.

United Nations, UN (1996). Indicators of Sustainable Development Framework and Methodologies, United Nations, New York.

United Nations Environment Programme, UNEP (2002). Vital Water Graphics. http://www.unep.org/vitalwater/28-dpsir.htm.

United Nations (2005a). Human Development Indicators, New York, pp. 211–222. URL: http://hdr.undp.org/reports/global/2005/pdf/HDR05_complete.pdf.

United Nations (2005b). Technical Note 1, The Human Development Index, United Nations Development Programme, New York, pp. 241. URL: http://hdr.undp.org/reports/global/2005/pdf/HDR05_complete.pdf.

World Health Organisation, WHO (1999). Environmental Health Indicators: Framework and Methodlogies, Protection of the Human Environment Occupational and Health Series. URL: http://whqlibdoc.who.int/hq/1999/WHO_SDE_OEH_99.10.pdf.

World Wildlife Fund (2000). Living Planet Report, pp. 10-21. URL: http://assets.panda.org/downloads/lpr2000.pdf.

World Wildlife Fund (2004). Living Planet Report, pp. 10-19, 24-31. URL: http://assets.panda.org/downloads/lpr2004.pdf.

World Wildlife Fund (2006). Ecological Footprint, World Wildlife Fund, Gland, pp. 14–19, 28–36. URL: http://assets.panda.org/downloads/living_planet_report.pdf.