SUSTAINABLE DEVELOPMENT INDICATORS FOR DECISION MAKING: CONCEPTS, METHODS, DEFINITION AND USE

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**Summary**

Indicators are ubiquitous in daily life, yet we lack access to information to monitor and measure (1) development in relation to the environment, (2) the impact and consequences of development processes on natural resources, ecological functions and society, and (3) the interrelationships among different development factors. In recent years a world consensus has been reached on the need for sustainable development. Such a changed perspective on development implies new demands, one of which is the
production of information that will play a critical role in providing a firm basis for evaluating decision making and monitoring development. Scientists and technicians are rarely able to provide decision-makers and the public with reliable information on the costs and benefits of development, or on social progress toward sustainability. The general absence of common methodological frameworks generates incompatible data, difficult-to-use information, and the multiplication of sets of indicators that are impossible to calibrate. Bringing methodological frameworks into agreement is not easy because it calls for a delicate balance between scientific validity, political acceptability, and technical feasibility. Indicators must therefore be developed in successive stages, and the different stages must be integrated. This paper demonstrates how indicators can be chosen to support development policy decision-making and clarify the needs and interests of different stakeholders. Indicators can be important tools to communicate scientific and technical information among different groups of users and to transform information into action toward sustainability.

1. Introduction

In daily life, we use many types of indicators to make multi-purpose decisions. Our bodies’ blood pressure, pulse, and temperature indicate our general health condition; the Gross Domestic Product, unemployment rates, and the rate of inflation are used to indicate the state and trends of a country’s or a region’s economy; while air pressure, temperature, and relative humidity are used to indicate and forecast the climate.

However, there is a lack of analogous information that would allow us to observe and monitor (1) development in relation to the environment, (2) the impact and consequences of development processes on natural resources, ecological functions, and society, and (3) the interrelationships among different development factors. As a consequence of this scarcity, the use of this type of information in routine decision making is limited. This situation restricts and hinders the effective application of the concept of sustainable development because, without good information, it is impossible to change concepts into actions. Therefore, scientists and technicians are rarely able to provide politicians, decision-makers, planners, and the public in general with reliable and comprehensible information on the benefits, costs, and effects of development paths and on the transition toward sustainability – or, at least, indications regarding the non-sustainability of development. In fact, most of the information on the forces driving development, the state of the environment and society, the impact generated on ecological functions and human well being is generally based on post hoc empirical evidence.

At the global, national, and regional levels, many institutions have numerous data and statistics on socioeconomic and environmental issues, but, in general, their production of information for decision making is poor. One reason for this is the lack of common methodological frameworks. Within the development context, these frameworks are crucial to determining the information required to recognize patterns, identify priorities, define policies, and implement actions. The absence of methodological frameworks generates incompatible data, difficult-to-use information, and the multiplication of sets of indicators that are impossible to adjust to one another. If indicators are to be used in decision making, then they must first be adjusted so that common sets of these indicators, responding to the needs of different users, can be selected. However, this process is not
easy because it requires, in addition to a good exchange of information, a delicate balance between scientific validity, political acceptability, and technical feasibility when developing and using these tools.

Indicators must therefore be developed in successive stages (from both technical and policy viewpoints). They must integrate the different stages involved in making decisions about development policies, as well as the needs and interests of different stakeholders. From the technical viewpoint, levels and scales must be established, causal relationships between development and environmental problems analyzed, and reference values defined. From the political viewpoint, consensus should be reached on the use and application of indicators, harmonizing conceptual and methodological frameworks, identifying priority problems and issues to be analyzed, and, finally, defining development goals to serve as reference values to guide future actions. Indicators thus become important tools to communicate scientific and technical information, and facilitate its access by different groups of users. In so doing, they can facilitate the transformation of information into action.

2. The Concepts of Sustainable Development and Decision Making

The notions of progress and well being are not new. Since ancient times, humankind has taken these concepts into account, although normally as implicit objectives within visions of development. Societies try to ensure their own survival, and even if no society has defined its own extinction as a development goal, this very result has often been a consequence of the development model adopted. One only needs to look at the Greek and Roman Empires, where their failure to adapt society and economy to the environment was probably the main cause of their decline and fall (Hughes, 1973).

Many human civilizations have used the concept of “health” to measure their level of well being, progress, or development, where “health” is defined as the balance or harmony between people and their environment (Bossel, 1999; Lovelock, 1992; Waltner-Toews, 1994). Within these civilizations many different tools were devised to monitor their “health”. These ideas have been displaced, however, by mechanistic and bio-medical models that are mainly based on the search for ways to tackle the unanticipated consequences of development (for instance, diseases), rather than on the identification of causes and the prevention of effects. Similarly, the concept of development has often been assimilated into that of economic growth; consequently, the tools available to monitor economic growth may be useful when analyzing various development components and their consequences. However, these tools are not suitable for analyzing causes, or, in particular, the interrelationships and synergistic effects among social, economic, and environmental components of development.
The concept of development can be incorporated into the “health” notion, as a process that implies progress and growth to achieve well being for both the individual and the society. Another important notion is that of the “viability” of sustainability (Bossel, 1999). This could be defined as the capacity of working, functioning or developing adequately. In order to determine “health” and “viability” of the development process it is therefore necessary to design tools that identify risk factors (driving forces), perform diagnoses (assessments) and prognoses (forecasts), and generate solutions (responses) in a way similar to that of human health (Table 1).

### 2.1. Sustainable Development

Sustainable development and sustainability have been defined in many different ways. These definitions have served many different purposes, thus the concept of sustainable development and its application has had many different scopes (de Camino and Muller, 1994; Hardi and Zdan, 1997; Moldan and Billharz, 1997; see also Basic Principles of Sustainable Development). Sustainable development is essentially a process of change that allows current human needs to be satisfied, without compromising the possibilities of future generations (WCED, 1987). It is achieved through the use and conservation of the natural resource base and the maintenance and expansion of the diversity of social, technological, and productive options (Winograd, 1995).

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Table 1: Indicators for Earth and Human Medicine: Methods and Tools
Source: Lovelock, 1992 (modified)

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<thead>
<tr>
<th>USE</th>
<th>METHODS</th>
<th>TOOLS</th>
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<tbody>
<tr>
<td>Driving Forces</td>
<td>Risk Test, Temperature, Breathing</td>
<td>Consumption Pattern, Satellite Radiometer, Atmospheric CO2</td>
</tr>
<tr>
<td>Diagnosis &amp; Forecast</td>
<td>Anatomic Analysis, Biochemical Analysis, Biopsy, Metabolic Analysis</td>
<td>Satellite Inventories, Water/Ar Quality, Ecosystems Studies, Flow Studies</td>
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<tr>
<td>Responses</td>
<td>Allopathic, Homeopathic</td>
<td>Limits of Emission, Environmental Education</td>
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Source: Lovelock, 1992 (modified)
Nevertheless, the concept of sustainable development implies, most importantly, the consideration of spatial (i.e. “where”) and temporal (i.e. “when”) dimensions, system components (i.e. economic, social and environmental aspects), and, in particular, the interactions between these components (i.e. “why, who, how, how much”). It refers at once to a process (development) and to a condition (sustainable). Development, like all system processes, is dynamic and a function of its dimensions and components. Sustainability, like all unbalanced system conditions, is complex and adaptive, and can be achieved via innumerable paths, yielding contrasting results for system components (Figure 1). In fact, many examples of “sustainability” can be found in nature and in human societies, with different and sometimes cruel consequences for ecosystems, species, and human populations.

Figure 1: Sustainable Development: Components, Scenarios, Consequences
Sustainability for mankind should be analyzed from the perspective of “accessibility domains” (Bossel, 1999; Hardi and Zdan, 1997), because not everything is possible nor desirable to maintain the well being of mankind, the natural resource base, and ecological functions that allow life on Earth (Figure 2). Physical, biological, social, and cultural constraints should be taken into account when defining sustainability and the tools required for its monitoring. Laws of nature, such as the flow of energy and matter, carrying capacity, and environmental constraints, cannot always be changed, eliminated, broken, or interrupted (Bossel, 1999; Lovelock, 1992; see also Biophysical Constraints to Economic Growth). Nor is it desirable to change, eliminate, break, or interrupt cultural and social patterns, and the role played by certain values and ethics. Finally, temporal and spatial dynamics cannot be ignored, because these set the pace and direction of evolutionary and development processes (Figures 1 and 2).
Although certain examples of sustainability exist for one of the system components, for example environmental sustainability based on a repressive policy of natural parks and reserves, they are not feasible from the social or economic viewpoints. For development to be sustainable, the capacities of all system components must be feasible and maintained, within the “accessibility domain” (Figures 1 and 2). As Figure 1 illustrates, development implies that system components act as open, linked balloons that are permanently fed by flows (for example, solar energy in the case of the environment, technology in the case of the economy, creativity in the case of the society). Sustainability is achieved when the flows between components (the balloons) make the system feasible because the capacities of the components are maintained.

In the last few years, the concept of sustainable development has spread to all levels of society. Nevertheless, one of the crucial points from the viewpoint of the real world - and regardless of the definition of sustainable development adopted or the objectives implied - is how the concept should and can be translated from theory into practice to make it functional. Therefore the absence of, constraints, and/or threats to sustainability must be known and information made available on where we come from, where we are right now, and where we are heading with respect to certain objectives or defined criteria. In other words, we need indicators for the system and its components to determine the direction in which we are moving or should or can move.

2.2. The Decision Making Cycle

Decision-making, in the development context, involves the design of a strategy, the definition of policies, and the execution of actions. Assessment and performance indicators must be used because decisions cannot be taken without information (UNEP-DPCSD, 1995). The decision making process therefore involves a series of commonly used data, statistics, and economic, social, and environmental indicators (UNEP, 1993; UNDP, 1998; World Bank, 1998; WRI, 1998). Decision making, just like development, is a dynamic process and is carried out at different levels of society, taking into account different cultural, social, economic, institutional, political, and environmental aspects. Therefore each stage of the decision-making cycle requires and uses different types of information (Figure 3).

The first stage of decision making involves identifying problems and risks, and creating an awareness about them, to be able to diagnose, based on assessment indicators, the state of the society, the economy, and the environment. Problems can then be monitored to provide information that will improve the decisions taken regarding actions on specific issues. Once the problems have been identified, then policies, strategies, and actions, based on multi-sectoral integration, should be formulated. Environmental and development problems obey multiple factors and have diverse consequences, and can be approached differently in political, economic, social, and cultural terms. By seeking equilibrium between existing and potential options, predictions can be made and a series of objectives and goals established to develop standards that can be used as reference values for implementing defined policies, strategies, and actions. The effectiveness and impact of adopted policies, strategies, and actions should also be evaluated. The fulfillment of objectives or goals and the progress made due to the measures that have
been taken, also need to be evaluated in order to tailor actions and strategies, and guarantee the participation of all stakeholders. Objectives and goals should be evaluated periodically on the basis of the circumstances, evolution, and perceptions of problems. In addition to assessment indicators, performance indicators should also be defined for all stages of the decision making process (Figure 3).

![Figure 3: Decision Making Cycle: Information Needed](image)

However, the goals, objectives, and standards must be first defined and applied at the national or local level. Societies should decide what goals and objectives they want to satisfy, how, and when. Some problems are global and/or regional, requiring international cooperation and the preparation and implementation of international treaties. In this case, objectives and goals are defined by consensus, which means that indicators are jointly defined and used for the different stages and levels of decision making.

### 3. Methods: How to Define Sustainable Development Indicators

Over millennia, humans have defined their situation in terms of wealth or plenty, in terms of indicators such as amount of land, heads of cattle, tons of grain produced, or ounces of gold. In recent years, other methods have been designed to estimate the situation of the economy, the society, and the environment, on the basis of a virtually endless number of indicators and indices (i.e. stocks of raw material, flow of materials, trends of production, market performance, financial assets, use of natural resources, etc.) (Adriaanse et al., 1997; Rodenbourg et al., 1995; Hammond et al., 1995; United Nations, 1998). These methods, however, provide insufficient information on sustainable development, particularly regarding the viability of development, the implications of rates of change, the importance of temporal and spatial dimensions, and the contribution of each component to the system as a whole (Bartelmus, 1994; Gallopín, 1996; Hammond et al., 1995; World
Bank, 1997; Winograd et al, 1998; WRI, 1998). Conceptual models and frameworks are therefore needed to:

- Identify components and characteristics pertinent to sustainable development.
- Determine and evaluate changes and characteristics of development components.
- Determine and evaluate the causes and effects of these characteristics on development.
- Assist in the preparation of development strategies, policies, and actions.
- Identify and assess the feasibility of the development process.

However, just as sustainable development has been defined in many ways, a large number of methods and models have been developed to define sustainability indicators. Several conceptual frameworks have been developed to guide the selection, development, and use of indicators (Bakkes et al., 1994; Hardi and Zdan, 1997; Moldan and Billharz, 1997).

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