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

Manuel Winograd *and* **Andrew Farrow**
International Centre for Tropical Agriculture (CIAT), Cali, Colombia

Keywords: Indicators, Sustainable Development, Decision Making, Information Tools, GIS, Temporal/Spatial Dimensions

Contents

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 bases 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

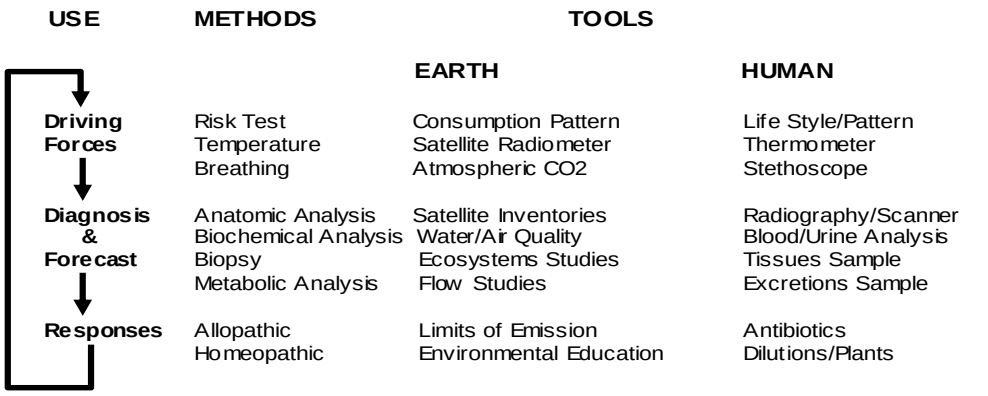
easy because it requires, in addition to a good exchange of information, a delicate balance between scientific validity, political acceptability, and technical feasibility when developing and using these tools.

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.



Source: Lovelock,1992 (modified)

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

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).

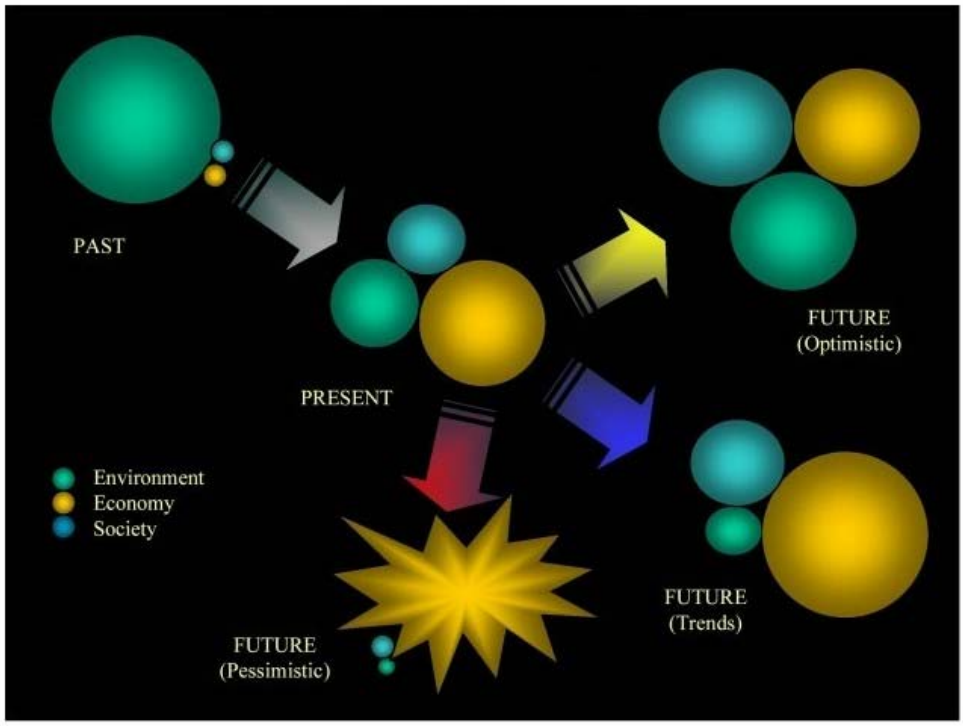


Figure 1: Sustainable Development: Components, Scenarios, Consequences

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.

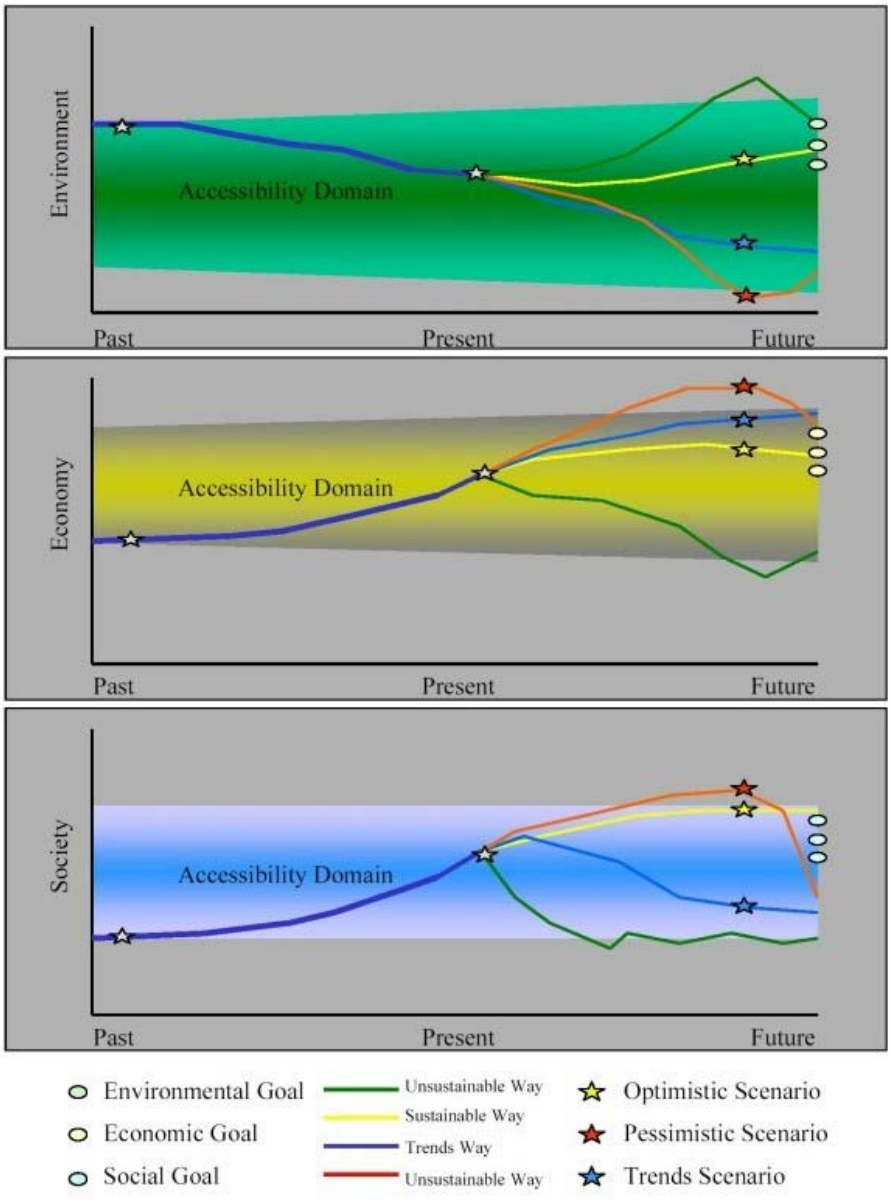


Figure 2: Sustainable Development: Accessibility Domains, Goals, Ways, Scenarios

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, can not 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).

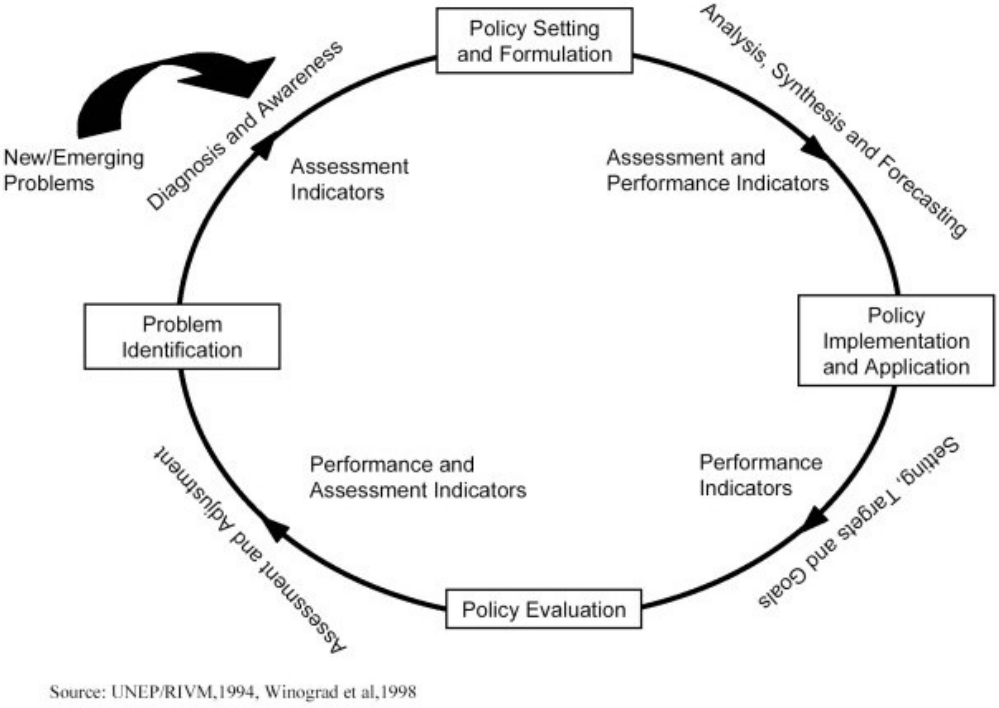


Figure 3: Decision Making Cycle: Information Needed

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 millenia, 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).

-
-
-

Bibliography

Adriaanse A. et al.,1997, *Resources Flows: The Material Basis of Industrial Economies*, World Resources Institute, Washington, D.C.. [Description of an indicator approach based on materials and resources use with case studies in different countries].

Adriaanse A.; 1993; *Environmental Policy Performance Indicators*, General of Environment of the Dutch Ministry of Housing, VROM, The Hague, The Netherlands. [First attempt showing the use of environmental indicators to measure performance and progress in policy and decision making].

Bakkes J. A., van den Born G., Helder J., Swart R., Hope C., Parker J.; 1994; *An Overview of Environmental Indicators: State of the Art and Perspectives*, Environment Assesment Technical Reports RIVM in co-operation with The University of Cambridgeand, UNEP-RIVM. [An assessment of the state of the art regarding different initiatives and frameworks to develop and use environmental indicators in the context of sustainable development].

Bartelmus P;1994; *Toward a Framework for Indicators of Sustainable Development*, Working Paper series # 7, Department of Economic and Social Information and Policy Analysis, ST/ESA/1994/WP.7, United Nations, New York. [The perspective from economic science to develop and use sustainability and environmental indicators].

Bossel H.; 1999; *Indicators for Sustainable Development: Theory, Method, Application*, Report to the Balaton Group, IISD, Winnipeg, Canada. [An integrative approach to develop and use sustainability indicators at different levels of decision].

CCME; 1994; *A Framework for Developing Goals, Objectives and Indicators for Ecosystem Health: Tools for Ecosystem-Based Management*, Water Quality Guidelines Task Group and the Canadian Council of Ministers of the Environment. [An approach to develop sustainability indicators based on ecosystems goods and

services].

CIAT, The World Bank and UNEP, 1999a, Rural Sustainability Indicators: Outlook for Central America, http://www.ciat.cgiar.org/indicators/index.htm [Description of the framework to develop and use sustainability indicators at regional, national and local levels of decisions].

CIAT, The World Bank and UNEP, 2000, *Developing Indicators: Experience from Central America*, Toolkit Folder, The World Bank, Washington, D.C. http://www.ciat.cgiar.org/indicators/index.htm [A complete publication package that contains CD with georeferenced indicators and information, examples of application at different scales and lessons learned].

CIAT, The World Bank and UNEP,1999b, Conceptual Framework to Develop and Use Water Indicators, Technical Note prepared by Manuel Winograd, Marta Aguilar, Andrew Farrow (CIAT) and Lisa Segnestam, Michael Linddal, John Dixon (World Bank), http://www.ciat.cgiar.org/indicators/wbank/news.htm [Description of a framework and indicators set to develop and use indicators in the case of sectoral approach].

de Camino R., S. Muller ;1993; *Sostenibilidad de la Agricultura y los Recursos Naturales: Bases para Establecer Indicadores, P*royecto IICA-GTZ, Serie Documentos de Programas # 38, IICA, Costa Rica, 133 pp. [Description of a practical development to develop and use sustainability indicators for agriculture and natural resources management].

DPCSD; 1996; I*ndicators of Sustaniable Development: Framework and Methodologies*, United Nations, New York. [Technical sheets describing how develop and use sustainability indicators in the context of the Pressure-State-Response framework].

EPA; 1995; *A Conceptual Framework to Support the Development and Use of Environmental Information for Decision-Making,* Environmental Statistics and Information Division, Office of Policy, Planning and Evaluation, EPA 230-R-95-012. [Description on the development and use of environmental indicators to support decisions].

EUROSTAT,1999, http://www.europa.eu.int/. [Description of initiatives to develop and use environmental indicators and information to help decision making and monitor development process].

Farrow A., M. Winograd, 1999, *Land Use Modeling at the Regional Scale: an input to Rural Sustainability Indicators for Central America,* paper presented at Workshop on Current Progress in Quantifying Spatially Explicit Causes and Effects of Land Use/Cover Change: Examples from Different Parts of the World, Wageningen University, Wageningen, The Netherlands, 7-8 December 1999. [Good example of application about the use of indicators and scenarios for policy and decision-making].

Farrow A., Winograd M., 2001, *Land Use Modelling at the Regional Scale: an input to Rural Sustainability Indicators for Central America*, In: Veldkamp, A., Lambin, E. (Eds.), Modelling land use/cover change from local to regional scales. Agriculture, Ecosystems and Environment. 85 (1-3):249 – 268 [Good example of application about the use of indicators and scenarios for policy and decision-making].

Friends A., Raport D.; 1979; *Towards a Comprehensive Framework for Environment Statistics: A Stress-Response Approach,* Statistics Canada, Ottawa, Canada. [First attempt to define a framework to develop and use environmental indicators].

Gallopín G.; 1996; Environmental and Sustainability indicators and the Concept of Situational Indicators: A Systems , Environmental Modeling and Assessment 1(3)101:118.[Description of a framework to develop and use indicators and the need to integrate environmental, social and economic information].

Hammond A., Adriaanse A., Rodemburg E., Bryant E., Woodward R.; 1995; E*nvironmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development*, World Resources Institute, Washington, D. C..[Description on the needs to integrate environmental indicators to measure and reporting sustainability progress].

Hardi P., T. Zdan (Editors), 1997, *Assessing Sustainable Development: Principles in Practice*, IISD,

Winnipeg, Canada.[Assessment and description on the practical principles to develop and use frameworks and indicators].

Holmberg J.; 1995; *Socio-Ecological Principles and Indicators for Sustainabilit*y, Institute of Physical Resource Theory, Goteborg, Sweden.[Good description about the need to integrate social, economic and environmental information to assses progress toward sustainability].

Hughes J.D., 1973, *Ecology of Ancient Civilizations*, The University of New Mexico Press, Albunquerque.[Description on the perception and use of concepts, natural resources management and its implication on the societies].

IFEN; 1996; I*ndicateurs de Performance Environmentale de la France, Institue Francais de l'Environment*, Diffusion Lavoisier, TEC & DOC, Paris, France.[Application and use of environmental indicators to assess progress toward sustainability].

Jackel C., 1997, *Using Arcview to Create Contigous and Noncontigous Area Cartograms*, Cartography and Geographic Information Systems, 2(2)101:109.[Some practical implications about the use of GIS to produce information].

Loh J. (Editor),2000, *Living Planet Report*, Published by World Wildlife Fund, World Conservation Monitoring Centre, Redefining Progress and The Center for Sustainable Studies, A Banson Production, London UK. [Good example of application of methods to measure the state of the world, with tabulated data and examples for all countries].

Lovelock J., 1992, *Healing GAIA: Practical Medicine for the Planet*, Harmony Books, New York.[An innovative approach to deal with changes and impacts in the environment and its implication for humankind and the planet].

Moldan B., S. Billharz (Editors);1997; S*ustainability Indicators: Report of the Project on Indicators of Sustainable Development*, John Wiley & Son, Sussex, England.[A complete state of the art compendium on the development and use of environmental and sustainability indicators].

OCDE; 1993; *OECD Core Set of Indicators for Environmental Performance Reviews*, Environmental Monograph # 83, OCDE, Paris, France. [Compendium of environmental indicator development and use to assess progress towards sustainability].

O'Connor J.; 1995; *Coping with Complexity*, Paper presented at 50 Session of ISI (International Statistical Institute), 21-29 August, 1995, Beijing, China.[Discussion on the different approaches and needs on information in function of users perspective and decisions].

Prescott-Allen R., 1999, *Barometer of Sustainability, http://www2.iucn.org/[Description on the methodology and application to develop and use indicators to measure sustainability]*.

Reid W., J. McNeely, D. Tunstall, D. Bryant, M. Winograd ; 1993; *Biodiversity Indicators for Policy-Makers*, World Resources Institute and The World Conservation Union, Washington, D.C..[Description and application of indicators development and use for a selected issue].

Rodemburg E., D. Tunstall, F. van Bolhuis; 1995; *Environmental Indicators for Global Cooperation*, Working Paper #1, Global Environmental Facility (GEF), UNDP/UNEP/The World Bank, Washington, D.C..[Description on the needs and use of environmental indicators in meassuring and assessing progress of global cooperation].

Rump P.; 1995; *State of the Environment Source Book*, RIVM-UNEP, Bilthoven, The Netherlands.[Compendium on the different initiatives and steps to produce environmental assessment using indicators].

Swart R., H. Bronswijk, B. J. Heij, L. Niessen ;1995; *Towards a Global Environmental Outlook: Integrated Global and Regional Environment Assessment*, Discussion paper prepared for GEO International Expert Meeting (CIAT, Cali, Colombia), RIVM, Bilthoven, The Netherlands.[Description on the needs and use of indicators to integrate environmental assessment at different scales and levels].

UNDP; 1998; *Human Development Report 1998*, Oxford University Press, New York. [The most important publication regarding human dimension of the development and social indicators. Yearly updated]

UNDP; 2000; Human Development Report 2000, Oxford University Press, New York. [The most important publication regarding human dimension of the development and social indicators. Yearly updated]

UNEP, 2000, *Global Environment Outlook (GEO-2000)*, UNEP and Earthscan, Earthscan Publications, London, UK. [An assessment about the state of the world's environment and the main actual and future issues. Examples using indicators for the world, regions and countries].

UNEP; 1993; *Environmental Data Report* 1993-94, Blackwell Reference, Oxford. [An assessment about the state of the world's environment. Examples using indicators for the world, regions and countries].

UNEP-DPCSD; 1995; *The Role of Indicators in Decision-Making*, Discussion Paper prepared by UNEP and DPCSD for the Indicators of Sustainable Development for Decision Making Workshop, 9-11 January, Ghent, Belgium.[Description on the use of indicators for decision and policy making].

United Nations,1998, *Measuring Changes in Consumption and Production Patterns: A Set of Indicators*, Department of Economic and Social Affairs, ST/ESA/264, UN, New York.[An approach to develop and use materials and resources indicators].

Wackernagel M., W. Rees; 1996; *Our Ecological Footprints*, Philadelphia New Society Publ., Grabiola, Canada.[Application of an approach to develop information about the use of resources with a common set of measures].

Waltner-Toews D.; 1994; *Ecosystem Health: A Framework for Implementing Sustainability in Agriculture*, Background Paper, pp 8-23 en Proceedings of an International Workshop Agroecosystem Health, June 19, University of Guelph, Ontario, Canada.[An approach to develop information based on ecosystems goods and services].

WCDE,1987, *Our Commnon Future: The Brundtland Report*, Oxford University Press, Oxford.[First definition and implications on sustainable development concept].

Winograd M,1997, Horizontal and Vertical Linkages in the Context of Sustainable Developent Indicators, in Moldan B. and Billharz S. (editors), Indicators of Sustainable Development, SCOPE, John Wiley and Son.[Description on the implications of different dimensions of the development to develop and use sustainability and environmental indicators].

Winograd M., A. Farrow, J. Eade, 1998, *Atlas de Indicadores Ambientales y de Sustentabilidad para America Latina y el Caribe: ATLAS CD*, CD-ROM, version 1, CIAT/PNUMA, Cali, Colombia. [A complete publication package that contains CD with georeferenced indicators and information].

Winograd M., Eade J., 1997, *Environmental and Sustainability Indicators for Latin America and the Caribbean: The Use of GIS (Geographic Information Systems)*, in Moldan B. and Billharz S. (editors), Indicators of Sustainable Development, SCOPE, John Wiley and Son.[Description on the findings about the development and use of indicators to measure progress in a region].

Winograd M., N. Fernandez, A. Farrow, 1998, *Tools for Making Decisions in Latin America and the Caribbean: Environmental Indicators and Geographical Information Systems*, Centro Internacional de Agricultura Tropical (CIAT) y Programa de las Naciones Unidas para el Medio Ambiente (PNUMA), Cali, Colombia. [Description on the findings and steps about the development and use of indicators to measure progress in a region].

Winograd M.; 1995; Environmental Indicators for Latin America and the Caribbean: Toward Land-Use Sustainability, GASE in collaboration with IICA/GTZ, OAS and WRI, Washington, D.C.. [A complete publication on indicators and statistics on environmental indicators]

World Bank, 1999, *Environmental Performance Indicators*. A Second Edition Note, The World Bank, Washington, D.C. An approach to develop environmental information based on measure progress in

policy and decision making]

World Bank, 2000, *The Little Green Data Book,* The World Bank, Washington, D.C. [A summary on environmental data and indicators from the world and all countries. A broad vision about the use of environmental, social and economic information].

World Bank; 1994; *Making Development Sustainable: From Concepts to Action*, I. Serageldin and A. Steer (editors), ESD Occasional Paper Series # 2, The World Bank, Washington, D.C.. [A broad vision about the application of concepts and the use of environmental, social and economic information].

World Bank; 1995; *Monitoring Environmental Progress: A Report on Work in Progress*, ESD Series, The World Bank, Washington, D.C.. [A compendium of initiatives about the application of concepts and the use of environmental, social and economic information].

World Bank; 1997; *Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development*, ESD Studies and Monographs # 17, Environment Department, Washington, D.C. [A compendium of initiatives about the application of concepts and the use of environmental, social and economic information].

World Bank; 1998; *World Development Indicators 1998*, The World Bank, Washington, D.C. [The most important publication regarding development and economic, social and environmental indicators at country level. Yearly updated].

World Bank; 2001; *World Development Indicators 2001*, The World Bank, Washington, D.C. [The most important publication regarding development and economic, social and environmental indicators at country level. Yearly updated].

World Economic Forum, Yale Center for Environmental Law and Policy and Center for International Earth Science Information Network, 2001, *Environmental Sustainability Index:* 2001, Yale Center for Environmental Law and Policy, USA. (http://www.ciesin.columbia.edu/indicators/ESI). [Application of aggregation indicators methods to evaluate and assess progress toward sustainability at national and regional level. Tabulated data and examples for all countries].

World Watch Institute, 2002, *State of the World 2002*, W.W. Norton Company, USA. [An assessment of the environment around the world with global and national information in particular on issues such as climate change, population, resource conflicts and global governance. Yearly updated].

WRI; 1996; *World Resources 1996-97*, Oxford University Press, New York. [The most important publication to evaluate the different dimensions of the development, with economic, social and environmental indicators at global, regional and country level. Bi-annual update].

WRI; 1998; *World Resources 1998-90: A Guide to the Global Environment,* Oxford University Press, New York. [The most important publication to evaluate the different dimensions of the development, with economic, social and environmental indicators at global, regional and country level. Bi-annual update].

WRI; 2000; *World Resources 2000-20001: People and Ecosystems,* World Resources Institute Series, Washington, D.C., USA. [The most important publication to evaluate the different dimensions of the development, with economic, social and environmental indicators at global, regional and country level. Bi-annual update].

Biographical Sketches

Manuel Winograd, has a Masters degree in Population Biology from Paris-7 University (France), a specialization degree in Environmental Sciences from the National Engineer School (Paris, France) and a PhD degree in Tropical Ecology from Paul Sabatier University (Toulouse, France). He was research fellow at the Institute of International Vegetation Map (Toulouse, France), associated researcher in the Ecological Systems Analysis Group at Fundacion Bariloche (Bariloche, Argentina) and international fellow at the World Resources Institute (Washington, D.C., USA). He is currently senior researcher in the Land Use Unit at the International Center for Tropical Agriculture (Cali, Colombia) and visiting scientist at the Centre de Cooperation Internationale en Recherche Agronomique pour le Developement (CIRAD,

Montpellier, France). He served as consultant for many international, regional and national institutions among others the World Bank, the United Nations Environment Program, the Inter-American Institute for Agriculture Cooperation, the United Nations Development Program the World Resources Institute and the Organization of American States. He was coordinator of different projects on sustainability indicators, rural development and environmental assessment in Latin America. He is author and co-author of different books; chapters, scientific articles and information products on sustainability and environmental indicators, decision-making tools and information, land use models and scenarios, rural development and agriculture and environmental assessment and monitoring. He developed the first series of CD-ROMs to use indicators and develop information for the Latin American region.

Andrew Farrow, has BSc degree on Geography and Surveying Science from Newcastle University (UK) and a Masters degree in Geographic Information Systems from Edinburgh University (UK). He was technical support analyst in Survey Supplies Ltd (UK) and research fellow in the Land Use Unit at the International Center for Tropical Agriculture (Cali, Colombia). He participated in different projects on sustainability and environmental indicators, rural development and land use and environmental assessment in Latin America where he developed GIS applications and interfaces, databases, land use models and information products. He is author and co-author of different books; chapters, scientific articles and information products on sustainability and environmental indicators, decision-making tools and information, land use models and scenarios, rural development and agriculture and environmental assessment and monitoring. He is currently studying the theme of spatial analysis of social vulnerability for a PhD in the Center for Environmental Risk at the University of East Anglia (UK) and is part time research fellow in the Land Use Unit at the International Center for Tropical Agriculture (Cali, Colombia).