SUSTAINABILITY INDICATORS:

A Bibliography with emphasis on Fishery Systems, Coastal Zones and Watersheds

Strategy for International Fisheries Research
Stratégie sur la recherche halieutique internationale

Sustainability Indicators:

An Annotated Bibliography

with emphasis on Fishery Systems, Coastal Zones and Watersheds

Anthony T. Charles

Department of Finance and Management Science
Saint Mary's University
Halifax, Nova Scotia B3H3C3 Canada

Research Assistance:

Cheryl Benjamin

SIFR (Strategy for International Fisheries Research) was established in 1992 to develop mechanisms for matching the research priorities of developing countries with the interests of donors. SIFR seeks to encourage the coordination in fisheries research for the sustainable development of living aquatic resources. High priority is given to strengthening the capacity of research institutions in developing countries to conduct applied research at the local and regional level. In addition, SIFR seeks to encourage support for strategic research through the CGIAR centres involved in living aquatic resource management.

SIFR is guided by a Steering Committee composed of representatives of the World Bank, UNDP, FAO, Commission of European Communities, IDRC, and NORAD. SIFR established a secretariat in 1993 to assist in the implementation of the SIFR strategy.

SIFR SECRETARIAT: 250 Albert Street, Box 8500, Ottawa, K1G 3H9 Canada.
Tel (613) 236-6163; Fax (613) 567-4349; Electronic mail BDAVY@IDRC.CA
Home Page Address: http://www.idrc.ca/sifr/

Published by SIFR (Strategy for International Fisheries Research)
250 Albert Street, Box 8500, Ottawa, K1G 3H9 Canada.

Canadian Cataloguing in Publication Data

Charles, Anthony, T.

Sustainability indicators : an annotated bibliography with emphasis on fishery systems, coastal zone and watersheds.

ISBN 0-88936-846-5

1. Sustainable fisheries -- Bibliography
2. Aquatic resources -- Bibliography
3. Coastal ecology--Bibliography
4. Ecosystem management--Bibliography
5. Aquatic ecology--Bibliography
6. Watershed management--Bibliography
I. Benjamin, Cheryl
II. .Strategy for International Fisheries Research (Association)
III. Title

Z5973.F56C42 1997 016.333.95'28 C97-980325X

Acknowledgements

Brian Davy provided the impetus for this study, as well as ongoing moral support and advice. Useful comments were received from Ken MacKay and Gary Newkirk. I am grateful to Cheryl Benjamin for her thorough work in compiling the material herein, and to Chris Milley and Garrett Manwaring for research support in the early stages of the study. Relevant material was supplied by many agencies, notably the International Development Research Centre, Canada (IDRC), the Food and Agriculture Organization of the United Nations (FAO), the United Nations Industrial Development Organization, and the United Nations Environment Programme. This research was supported financially by the International Development Research Centre of Canada (IDRC).

Table of Contents

1. Introduction

There is a clearly emerging consensus that the world's coastlines and watersheds are of fundamental importance to human well-being, that these systems are increasingly threatened by economic change and environmental degradation, and that consequentially, urgent attention is needed. To provide this effectively, it is important to accurately assess the current state of these aquatic systems, and to predict the consequences of policies for improvement. Addressing these needs requires quantitative approaches, through which the sustainability of relevant systems can be measured. This is the idea of "sustainability indicators". The creation of this bibliography began, therefore, with the specific question: What efforts have been made to develop and analyse quantitative indicators of sustainability in fishery systems, coastal zones and watersheds?

The initial goal was to compile available references that address, in an integrated and multi-disciplinary manner, the development of quantitative sustainability indicators for aquatic systems. However, it became apparent that little was published on that specific theme. Therefore, the scope of the bibliography was broadened to add related topics on sustainability both in aquatic and non-aquatic systems. The resulting 245 references in this bibliography have been organized into three major sections, and several sub-sections, described below.

Approaches to Evaluating Sustainability in Aquatic Systems (114 references)

Searches of the available literature uncovered very few references combining analysis of aquatic systems with presentation of sustainability indicators that are both quantitative and integrated (interdisciplinary). However, a substantial number of references deal with sustainability in aquatic systems either (i) in an integrated manner, whether quantitatively or qualitatively, but typically without the use of indicators, or (ii) in a quantitative manner, but solely with environmental or "ecosystem health" aspects. These various references have been organized in three sub-sections:

- Fishery and Aquaculture Systems (36 references)
- Coastal Zone and Watershed Systems (35 references)
- Environmental and Ecosystem Health Indicators (43 references).

In most cases, the "integrated" references in the first two sub-sections present or reflect multi-dimensional approaches to addressing sustainability, typically from the perspectives of both the natural and the human sub-systems. Among the themes dealt with are sustainability concepts in fisheries and aquatic ecosystems, social and economic valuation of aquatic resources and ecosystems, integrated fishery modelling, and policy analysis for sustainable fisheries. On the other hand, references in the third subsection reflect a substantial body of research, dealing from a more restricted scientific (particularly biologically-oriented) view with indicators of environmental and ecosystem health in aquatic systems. This body of work can be viewed as providing a strong starting point for development of an integrated approach that also incorporates economic, social, institutional and community considerations.

Sustainability Indicators for General and Non-Aquatic Systems (65 references)

This section of the bibliography includes references on (usually quantitative) indicators of sustainability that can be placed in three categories:

- general and/or theoretical papers, dealing with methodological and conceptual matters, not specific to any one resource type or ecological zone (9 references)

- agricultural and other "non-aquatic" resource systems, including forests, rangelands and wildlife (38 references); these include analysis at local ("micro"), regional or industry levels; for example, this might involve indicators of sustainability for forestry operations in a specific location, or for wildlife management in a specific park.

- international or national settings (18 references); such studies involve quantitative sustainability indicators at the "macro" (e.g. macro-economic) level, notably the development of alternative national accounts (natural resource accounting, or "green" accounting), and alternative indicators of human progress and well-being, to replace the GNP or GDP.

Background: Non-Aquatic Systems (66 references)

This final section contains publications not fitting within one of the above headings, but providing relevant theoretical or practical background on the development of quantitative sustainability indicators. Among the themes included are:

- sustainability concepts
- social and economic valuation of environmental and resource systems
- integrated resource and environmental modelling
- policy analysis related to sustainability of forestry, agriculture, range and wildlife management, and other resource systems.

Note that references on the above subjects, but connected with aquatic systems, are included in the first section of the report, described above.

Throughout the report, references are presented in alphabetical order within each section (and sub-section). Each bibliographic citation provides the usual information, plus [in square brackets] the author's institution at time of publication, if available. The citation is followed in most cases by one of: the abstract, an extract from the text of the publication, the publication's table of contents, or a summary prepared during compilation of the bibliography. (In a small number of cases, neither the full publication nor the abstract was available, yet from the title, the publication appeared sufficiently relevant to list its bibliographic citation herein.)

Apologies are made in advance for any mis-classifications of references in the process of allocating to thematic sections, and for any omissions of relevant material, unavoidable given the rapid expansion of literature on sustainability. (It should be noted as well that no attempt was made to provide exhaustive coverage of peripheral topics, such as national and international sustainability indicators, or of background material.) Despite these caveats, it is hoped that this bibliography will be helpful in the challenging pursuit of sustainability for aquatic systems.

2. Approaches to Evaluating Sustainability in Aquatic Systems

2.1 Fishery and Aquaculture Systems

Berkes, F. and Shaw, A.B. 1986. Ecologically Sustainable Development: A Caribbean Fisheries Case Study. Canadian Journal of Development Studies; Vol. 7, pp. 175-196. [Brock University, St. Catherine's, Ontario, Canada]

"Self-sufficiency in fish production has been an elusive goal of many Eastern Caribbean nations despite decades of fishery development. The thrust and the outcome of fishery (development) strategies have been quite different in Barbados and Jamaica and have resulted in the orientation of effort to different fish resource types. Barbados has a major offshore fleet while Jamaica has a large reef fishery but no offshore fleet. An analysis of these fisheries is used to develop a broad concept of development incorporating a range of concerns, from the long-term sustainability of the resource base (the sustainable development approach), to the socioeconomic development of fishermen." [Abstract]

Cella, G.; Placenti, V. and Spagnolo, M. 1994. Evaluating socio-economic impact of EEC fishery policy using a social accounting matrices approach. In: M. Antona, J. Catazano and J.G. Sutinen (editors). Proceedings of the Sixth Conference of the International Institute of Fisheries Economics and Trade. [Istituto Ricerche Economiche per la Pesca e l'Acquacultura (IREPA), Salerno, Italy]

"EC policy is directed to reduce fishing effort all over the Community in order to balance available resources. The impact of such a policy will affect, in economic and social terms, the fishing sector directly, but also related sectors will be heavily influenced.

Aim of the paper is to suggest and apply a methodological scheme to approach evaluation of socio-economic impacts of EC fishery policy at sub-regional level within a general planning framework. In this respect the relevant approach tends to identify geographical areas highly dependent on fisheries. This methodology can show to be useful in case of concentrated fisheries communities, but it is of little use when the activity is widespread all over the Country, as it is in the case of Mediterranean fisheries. In any case, the evaluation of socioeconomic impact of variations in the scale of fishing should take account, not just the direct effects of the activity, but also the effects variations will have on the rest of the economic system through the interdependencies of sectors - the indirect effects. The impact of the overall effects of a reduction in fisheries and related sectors takes into account the roles of production, intermediate and final consumption and investment. The quantification of the effects can be undertaken using Social Accounting Matrices (SAM) which delineate existing interrelationships in the economic system. This approach is developed in the paper and the analysis has been applied to five administrative Italian regions. Results are reported and

expressed in terms of four indicators of a socioeconomic character: the value of gross output, value added, incomes earned by employees and employment." [Abstract]

Chakalall, B. 1992. Sustainable fisheries development in the Caribbean. In: B. Chakalall (editor). Report and Proceedings of the Meeting on Fisheries Exploitation within the Exclusive Economic Zones of English-speaking Caribbean Countries, St. George's, Grenada, 12-14 February 1992. FAO Fisheries Report No. 483. Food and Agricultural Organization of the United Nations, Rome, Italy. [FAO Regional Office for Latin America and the Caribbean, Santiago, Chile]

"The final report and the papers presented at the Meeting on Fisheries Exploitation within the EEZs of English-speaking Caribbean Countries held in St. George's, Grenada, 12-14 February 1992, form Parts 1 and 2 of this report.

Part 1 of the volume summarises the discussions of the main issues that arose from the national reports and the technical papers presented at the Meeting. It contains the conclusions and recommendations made by the meeting. The principal recommendation was policy guidelines for obtaining maximum sustainable benefits from the exploitation of the fisheries resources within the EEZs. In this regard, governments were requested to review and refine their national policies for the development and management of the various fishery types within their EEZ and prepare comprehensive management and development plans for these fisheries.

Part 2 contains the national reports of the countries represented at the Meeting, and the technical papers prepared for and presented at the Meeting. The topics covered by these documents include policy issues, legal regime for EEZ management, status of the resources, case studies on the living resources of the EEZ of Trinidad and Tobago and of the OECS countries, and methodological and operational aspects of statistical monitoring systems in the Caribbean." [Abstract]

Chapman, M. 1991. Basic elements in the sustainable development of fisheries: implications for aid programs in developing countries. Resource Management and Optimization; Vol. 9, No. 1, pp. 71-83. [Griffith University, Nathan, Brisbane, Queensland, Australia]

"Many aid programs are increasingly concerned with ensuring the sustainable development of resources in developing countries. In the case of common property resources such as fisheries, 'traditional' is often equated with 'sustainable' and much work is now focused upon the apparent link between traditional access control mechanisms such as territoriality, and sustainability of resources use. While recognizing the importance of such factors, it is suggested that they are only one element in a much broader network of factors necessary for sustainable fisheries development. What these factors are and how they relate to effective fisheries aid programs in developing countries is discussed." [Abstract]

Charles, A.T. 1997. Fisheries in Transition. In: Ocean Yearbook 1997. University of Chicago Press, Chicago, Illinois, United States. [Saint Mary's University, Halifax, Nova Scotia, Canada]

This paper first examines competing visions of fishery use and management, and their implications. It then provides a multi-dimensional definition of fishery sustainability, and develops a methodology of sustainability assessment in fisheries, based on a sustainability checklist, together with sets of ecological, socioeconomic, community and institutional sustainability indicators. New directions in fisheries research are discussed. Finally, the impacts of external economic, social and technological forces on the fisheries are discussed.

Charles, A.T. 1994. Towards sustainability: the fishery experience. Ecological Economics; Vol. 11, pp. 201-211. [Department of Finance and Management Science, Saint Mary's University, Halifax, Nova Scotia, Canada]

"The fishery, with its inherent complexity and its long history of debate over matters of sustainability, provides an important case study on sustainable development and the routes to its achievement. This paper (a) reviews the evolution of sustainability concepts and management paradigms in the fishery, (b) draws on this experience to develop an integrated 'sustainability assessment' framework involving the evaluation of Ecological, Socioeconomic, Community, and Institutional sustainability, and (c) analyses potential policy directions for sustainable development. The latter include: use of adaptive management measures to 'live with uncertainty,' development of integrated strategies to cope with resource system complexity, enhancement of local control and decision making, establishment of appropriate property rights systems, and the combination of comprehensive planning with economic diversification." [Abstract]

Charles, A.T.; Brainerd, T.R.; Bermudez M., A.; Montalvo, H.M. and Pomeroy, R.S. 1994. Fisheries Socioeconomics in the Developing World: Regional Assessments and an Annotated Bibliography. International Development Research Centre, Ottawa, Ontario, Canada. [Department of Finance and Management Science, Saint Mary's University, Halifax, Nova Scotia, Canada]

"In fisheries of the developing world, where social and economic concerns often dominate, intelligent policy making requires an adequate understanding of both 'economic' and 'human' factors - the economic structure and dynamics of the fishery system, on the one hand, and the role of social, cultural, institutional and political aspects on the other. Interdisciplinary linkages between these two elements form the essence of fishery socioeconomics, which addresses a wide range of topics: analyses of management and developmental goals, income distribution, social accounting, fishery ownership and access, fisher dynamics and labor markets, the socioeconomic structure of fishing communities, economic aspects of gender differences, the nature of fishery decision making, and so on.

Despite its recognized practical importance, the fishery socioeconomics literature is widely dispersed and often inaccessible. This report presents the results of an international effort to compile this literature and to assess the 'state of the art' in socioeconomic research on developing fisheries and aquaculture. The report consists of two key elements: (1) a series of regionally-based assessments of fishery socioeconomics research, for each of Africa, Latin America and Asia/Pacific, and (2) an extensive annotated bibliography (on diskette) containing over 1100 references from across the developing world." [Abstract]

Christie, W.J. 1993. Developing the Concept of Sustainable Fisheries. Journal of Aquatic Ecosystem Health; Vol. 2, pp. 99-109. [Picton, Ontario, Canada]

"We are approaching the limits to World fish yields, and it is becoming increasingly difficult to sustain the stocks in the face of allocative disputes between fisheries and competing water uses. A new strategy is needed to integrate aquatic ecosystem management into the larger context of Environmentally Sustainable Development. This will need to span jurisdictions and interest sectors in long-range environment-economy planning. It is suggested that this process is impossible within conventional government infrastructures, and that a new movement is needed, involving multi-sector, independent public participation." [Abstract]

Dunn, E. 1996. Fisheries and the Development of Sustainability Indicators. North Sea Monitor; June 1996, pp. 13-19. [Royal Society for the Protection of Birds, U.K.]

"The goal of sustainability is at the heart of virtually every fishery policy but it is proving very difficult to deliver in practice. A range of fisheries statistics is available which include trends in fish stocks, and related socio-economic and environmental dimensions. This article explores the use of indicators in developing sustainable fisheries." [Abstract]

FAO. 1992. Report of the Consultation on Sustainable Development and Environment in the Agriculture, Forestry, and Fisheries Sectors in Latin America and the Caribbean: Santiago, Chile, April 28-30 1992. FAO Regional Office for Latin America and the Caribbean, Santiago, Chile.

Folke, C. and Kautsky, N. 1992. Aquaculture with its Environment: Prospects for Sustainability. Ocean and Coastal Management; Vol. 17, No. 1, pp. 5-24. [Department of Systems Ecology, Stockholm University, Stockholm, Sweden]

"The rapid expansion of intensive one-species aquaculture has generated severe environmental as well as socio-economic problems. A major reason is that Western-oriented aquaculture has been managed as an isolated part of its supporting environ-

ment. In this paper, the authors compare the use of industrial energy for various aquaculture, fisheries and agriculture systems and analyze the connection between resource use, methods of culturing and environmental impacts. The characteristics of one-species aquaculture, such as intensive throughput-based salmon cage-farming and shrimp pond-farming, are found to be similar to those of stressed ecosystems. Among these characteristics are a very inefficient resource use and generation of by-products that are stored or exported. Because of the problems with these monocultures, there is a great need for Western-oriented aquaculture to redirect the industry's present behavior towards a path of synergy between development and environment. Based on principles of ecological engineering, Chinese integrated systems are synthesized, intensive mangrove-destructing shrimp farming is opposed to integrated shrimp farming, and how a coastal culturing system of seaweeds, mussels and salmon could be developed is suggested. Such systems aim at increased efficiency, reduced resource use, avoidance of chemicals and medicals, less waste generation and the recycling of nutrients and materials. The authors conclude that the more a cultivation system recognizes and mimics natural ecosystem functions the less environmental effects can be expected. A successful aquaculture system does not have wastes, only by-products, to be used as positive contributors to the surrounding ecosystems and the economy." [Abstract]

Folke, C. and Kautsky, N. 1989. The role of ecosystems for a sustainable development of aquaculture. Ambio; Vol. 18, No. 4, pp. 234-243. [Asko Laboratory, University of Stockholm, Stockholm, Sweden]

"This paper discusses the basis for cage culturing of salmonids and mussel long-line rearing in Scandinavian marine aquaculture, it also includes a discussion on the support that is required from the marine environment to sustain production; how aquaculture fits into the marine ecosystem; and what side-effects and changes it may cause. Local, as well as regional, environmental effects are evaluated and related to the growth and economic development of the aquaculture industry." [from Abstract]

Garcia, S.M. 1994. The Precautionary Principle: its Implications in Capture Fisheries Management. Ocean and Coastal Management; Vol. 22, pp. 99-125. [Fisheries Department, FAO, Rome, Italy]

"The paper attempts to clarify the research, management and legal implications of a potential application of the Precautionary Principle to capture fisheries, particularly in the international contest. In rite process, the paper also looks at related issues such as the burden of proof, the use of best available scientific evidence and technology, the reliance on prior scientific consensus, assimilative capacity and acceptable levels of impacts, etc., in the fishery context. It is argued that, if narrowly interpreted, the precautionary principle could lead to socioeconomic havoc. If reasonably interpreted, however, the Principle offers a golden opportunity to progress towards sustainable fisheries development and suggestions are made for the implementation of precautionary approaches in fisheries management." [Abstract]

Hammer, M. 1991. Marine Ecosystem Support to Fisheries and Fish Trade. In: C. Folke and T. Kaberger (editors). Linking the Natural Environment and the Economy: Essays From the Eco-Eco Group. Kluwer Academic Publishers, Dordrecht, The Netherlands. [Department of Systems Ecology, Stockholm University, Stockholm, Sweden]

"The relationships between fish production in marine ecosystems and fish processed and traded in the economy is analysed for Sweden's foreign trade in herring, cod, salmon and fish meal for 1986. Estimates are made of direct and indirect energy requirements in the marine ecosystem and the economy to produce the fish products. A comparison is made of trade balances in economic terms expressed as export and import prices and in energy terms, expressed in solar energy terms. In monetary terms imports are 2.5 times larger than exports, but in energy terms about 7.3 times larger than exports meaning that Sweden is receiving products and work performed in the marine ecosystems at a lower price than it is selling its own products. This indicates that Sweden is dependent on much larger ecosystem support areas performing necessary work than is reflected in standard economic evaluation. The importance of considering such ecosystem support in economic decision making and management of indigenous and foreign living marine resources is emphasized." [Abstract]

Hammer, M.; Jansson, A-M. and Jansson, B-O. 1993. Diversity Change and Sustainability: Implications for Fisheries. Ambio; Vol. 22, No. 2-3, pp. 97-105. [Department of Systems Ecology, Stockholm University, Stockholm, Sweden]

"Conserving biodiversity is regarded one of the major issues for enabling sustainable use of natural resources. This paper, focusing on the Baltic Sea and Sweden's fisheries, emphasizes the value of preserving biodiversity for the maintenance of diverse, resilient and functioning ecological life-support systems. These constitute a fundamental and necessary base for all human activities. The major features of diversity: species diversity, genetic diversity, functional diversity, and spatial and temporal diversity and diversity changes in the Baltic Sea ecosystem are described and discussed together with the development of management approaches in Sweden's fisheries. The paper takes a systems perspective, focusing on the linkages between ecological and economic systems. Biodiversity is seen as an interdependent part of the cluster of diversities in the human society and in the ecological system. The need for broader integrated approaches enhancing diversity in resource-management systems are emphasized." [Abstract]

Henderson, M.A. and Healy, M.C. 1993. Doubling Sockeye Salmon Production in the Fraser River - Is This Sustainable Development? Environmental Management; Vol. 17, No. 6, pp. 719-728. [Department of Fisheries and Oceans, Vancouver, British Columbia, Canada]

"We evaluate a proposal to double sockeye salmon production from the Fraser River and conclude that significant changes will be required to current management processes, particularly the way available catch is allocated, if the plan is to be consistent with five major principles embodied in the concept of sustainable development. Doubling sockeye salmon production will not, in itself, increase economic equity either regionally or globally. Developing nations may actually be hindered in their attempts to institute other, nonsalmon fisheries in the North Pacific Ocean as a result of the possible interception of salmon. Further, other users of the Fraser River basin will have to forego opportunities so that salmon habitat can be conserved. If doubling sockeye salmon production is to meet the goal of doing more with less, it will be necessary to develop more efficient technologies to harvest the fish. If increasing salmon production is to reflect the integration of environmental and economic decision making at the highest level, then a serious attempt must be made to incorporate environmental assets into national economic accounting. Finally, to promote biodiversity and cultural self-sufficiency within the Fraser River basin, it will be important to safeguard the small, less-productive salmon stocks as well as the large ones and to allocate a substantial portion on the increased production to the Native Indian community." [Abstract]

Hodgson, G. and Dixon, J.A. 1988. Logging Versus Fisheries and Tourism in Palawan: An Environmental and Economic Analysis. East-West Environment and Policy Institute Occasional Paper No. 7.

"The pollution of rivers, lakes, and sea by sedimentation is a growing problem throughout the world. Sedimentation pollution of coastal marine areas is especially serious in Southeast Asia where fish harvested from coastal waters serve both as a major source of protein for human consumption and a significant source of foreign exchange through exports. One major cause of sedimentation is logging...

In order to examine the economic effect of sedimentation pollution on tourism and marine fisheries, predictions of future revenue production based on two development alternatives are presented. The development options are (1) to ban logging in the bay's watershed or (2) to allow logging to continue as planned. The first option would prevent further damage to the bay's ecosystem due to logging-induced sedimentation and thus the tourism and marine fisheries dependent on it. The second option would maximize logging revenue but reduce revenue from the other industries.

The results of the economic analysis are striking and project a reduction in gross revenue of more than $40 million over a 10-year period with continued logging of the Bacuit Bay watershed as compared with gross revenue given implementation of a logging ban. The difference is due to projected losses from tourism and fisheries. Present value analysis was performed using both a 10 and 15 percent discount rate. Even with the higher discount rate, the present value of lost revenue exceeds $11 million under Option 2 - continued logging. Sensitivity analysis shows that significant deviation from predicted effects of sedimentation damage do not alter the conclusion. In addition to the quantitative results consideration of qualitative factors reveals that the

social, economic, and environmental benefits of fisheries and tourism outweigh those of logging in this location.

The study demonstrates that the combined use of ecological and economic analyses can provide useful information for government planners seeking to maximize not only economic benefits while minimizing social and environmental costs. Recommendations are made regarding application of these results to similar resource conflicts in other regions." [from Abstract]

Jones, H. 1994. Fisheries ecologically sustainable development: terms and concepts. Institute of Antarctic and Southern Ocean Studies, University of Tasmania, Tasmania, Australia.

An anthology and glossary taken from dictionaries, books, scientific reports, papers and the like with the addition of some comments.

Kautsky, N. and Folke, C. 1989. Management of coastal areas for a sustainable development of aquaculture. Biota; Vol. 5, No. 1-2, pp. 1-11. [Askoe Laboratory, University of Stockholm, Stockholm, Sweden]

"The large scale impact on ecosystems of some common aquaculture activities was evaluated. Seaweed culture and mussel long-line rearing represented a self-regulated extensive aquaculture systems and integrated with the natural marine environmental and salmonid cage farming. A combination of seaweed, mussel and fish culture in the same water body was proposed as a means of increasing total productivity and reducing overall environmental impacts." [Abstract]

Khorshid, M. and Morgan, G.R. 1990. A Modelling Framework for Fisheries Development Planning. Ocean and Shoreline Management; Vol. 14, No. 1, pp. 11-33. [Techno-Economics Division, Kuwait Institute of Scientific Research (KISR), Kuwait and Cairo University, Giza, Egypt]

"An approach to model building is described which begins with the establishment of a matrix reflecting the basic features of the fisheries sector, and then proceeds to incorporate these features into a model structure. The model includes a set of policy objectives and constraints, and is formulated as a mathematical programming problem. The modelling framework enables quantitative data on fish resources, production techniques (including aquaculture), market demand forecasts and other biological, economic and marketing parameters to be utilized in assessing the implications of various fishery policy objectives. The model not only estimates the real cost of alternative policies but also takes into account the various biological and economic constraints to production. Rapid assessment of a range of policy objectives is therefore made possible. As an example of the application of the modelling framework, the development of a fisheries sector plan for Kuwait is described. Such planning involved

establishing the most appropriate way to maximize fresh fish self-sufficiency while reconciling the production from a multi-gear, multi-species capture fishery with the need to develop an aquaculture industry in the country. The modelling framework allowed the rapid identification of appropriate development policies consistent with the biological, economic and marketing constraints of the fisheries sector and also allowed an assessment of the cost of each policy objective." [Abstract]

Knuth, B.A. 1986. A fisheries and wildlife resource indicator system for use in natural resource management. Ph. D. Thesis, Virginia Polytechnic Institute and State University. University Microfilms International, Ann Arbor, Michigan, U.S.

Knuth, B.A. and Nielsen, L.A. 1989. Social and Institutional Performance Indicators for Wildlife and Fishery Resource Management Systems. Society and Natural Resources; Vol. 2, No. 4, pp. 329-344. [Department of Natural Resources, Cornell University, Ithaca, New York, United States]

"Following a model based on the development and use of social indicators in the field of public administration, the article describes a system of wildlife and fishery resource management indicators for all dimensions of the resource management complex. The system includes a comprehensive series of biological, social, and institutional dimensions. These dimensions are arrayed with four management system components - inputs, processes, outputs, and impacts - to form a 16-cell matrix containing 377 resource management indicators. Social and institutional dimensions are discussed as being most in need of explicit management attention. The indicator system has utility for improving all phases of the management process, from goal- and objective-setting through evaluation." [Abstract]

Konstapel, K. and Noort, L. (editors). 1995. Fisheries in Developing Countries - Towards sustainable use of living aquatic resources. Sectoral policy document of Development Cooperation 9. Ministry of Foreign Affairs, Development Cooperation Information Department, The Hague, Netherlands.

"This document is arranged as follows: Chapter 2 sketches an outline of the current state of affairs in the fisheries sector on a global level. In chapter 3 the need for sustainable management of the fisheries sector is defined and substantiated after which, in chapter 4, the situation in developing countries is described. The options for intervention in the context of Dutch policy are described in chapter 5, then in chapter 6 the choice of channels for support to the fisheries sector is examined. Annexes A and B provide guidelines which may be useful in the appraisal of activities in the subsectors of artisanal fishery and small-scale aquaculture." [from Introduction]

Lane, D.E. and Stephenson, R.L. 1995. Fisheries management science: the framework to link biological, economic, and social objectives in fisheries management. Aquatic Living Resources; Vol. 8, No. 3, pp. 215-221. [Faculty of Administration, University of Ottawa, Ottawa, Ontario, Canada]

"Fisheries management in the future will require that biological assessments be combined appropriately with operational, social, and economic considerations toward effective management of complex fisheries systems. This is not currently being done in fisheries management because of: (i) the lack of a conceptual and organizational framework for integrated and participatory decision making, and (ii) the lack of more appropriate methodologies for dealing with diverse sources of information, interdisciplinary objectives, and the inherent uncertainty of these systems. An integration of traditional 'fisheries science' with other aspects of 'fisheries management' and the field of 'management science' in a new discipline of 'Fisheries Management Science' is proposed. FMS is defined as 'the rigorous application of the scientific method of problem solving in the development of strategic alternatives and their evaluation on the basis of objectives that integrate biological, economic, social and operational factors into management decision making'.

Management science or operational research provides guidance in methodologies for complex decision making and problem resolution. A multidisciplinary decision framework is proposed involving the following key steps: (1) specification of quantifiable objectives and constraints; (2) modeling of the expected multicriteria performance of a range of proposed management decisions; (3) risk assessment through descriptions of the expected variability in performance measures; (4) risk management through analytical evaluation of risk and ranking of alternate solutions; and (5) continuous monitoring and improvement of past decisions including deviations from expected performance and corresponding adjustment of future alternatives toward achieving strategic objectives." [Abstract]

Lightfoot, C.; Gupta, M.V. and Ahmed, M. 1992. Low External Input Sustainable Aquaculture for Bangladesh - An Operational Framework. NAGA, The ICLARM Quarterly; Vol. 15, No. 3, pp. 9-12.

This article provides an operational framework for development of sustainable aquaculture, utilizing low levels of external inputs, and complementing other agricultural activities. The discussion is focused on application to Bangladesh; that country's Agricultural Research Council, Fisheries Research Institute and Department of Fisheries collaborated with ICLARM on this project.

MacKay, K.T. 1993. Sustainable Management of Fisheries Resources: Common Property Issues. In: Juinio-Menez, M.A. and Newkirk, G.F. (editors). Philippine Coastal Resources Under Stress: Selected papers from the Fourth Annual Common Property Conference held in Manila, Philippines, June 16-19, 1993. Coastal Resources

Research Network, Dalhousie University, Halifax, Nova Scotia, Canada and Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines.

"...There are a few examples from South-East Asia and the Pacific Islands to indicate that a community-based fisheries management may result in sustainable resource utilization. Examination of such management of common property may help us to develop approaches that can be applied elsewhere to increase the sustainable management of coastal systems.

This paper applies a framework developed from an analysis of traditional common property management to some preliminary attempts at implementing community based management in the Philippines." [from Abstract]

MacKay, K.T. 1991. Sustainability and entry points. ILEIA Newsletter; May, 1991.

"One change in a farm system that appears to lead to a large number of other beneficial changes and appears to enhance the evolution of the system, may be called an 'entry point'. Changes like this are usually made by farmers and are often unanticipated by researchers. Ken MacKay indicates how carefully chosen diversity may increase the sustainability of systems. Even though rice-fish culture in Northeast Thailand has recently become more difficult due to drought, the entry point concept may be an important methodological tool in assessing sustainability." [Abstract]

MacKay, K.T. 1983. Ecological Aquaculture, New Approaches to Aquaculture in North America. Journal of the World Mariculture Society; Vol. 14, pp. 704-713. [IDRC, Ottawa, Ontario, Canada]

"Existing aquaculture systems in North America are energy intensive. For example, rainbow trout production in raceways requires an energy subsidy of 81 MJ/kg while catfish pond production requires 44 MJ/kg; both are more energy intensive than feed lot beef production. An alternative approach, 'ecological aquaculture,' has been practised for centuries in Asia but has only recently been applied in North America. Ecological aquaculture is energy efficient, recycles waste, minimizes environmental impact, and is integrated with other food production systems. This paper discusses the principles of ecological aquaculture and illustrates them with examples from North American operations. Such operations range from extensive culture of rainbow trout in small productive prairie ponds to greenhouse water recirculation systems with fish supplying the nutrients for hydroponic crop production. Other examples are backyard fish production systems and polyculture pond systems fertilized by pig manure." [Abstract]

McGlade, J.M. 1989. Integrated Fisheries Management Models: Understanding the Limits to Marine Resource Exploitation. American Fisheries Society Symposium; Vol. 6, pp. 139-165. [Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada]

"Integrated fisheries management (IFM) models incorporating ecological, socioeconomic, legal, and institutional aspects of a fishery can be used to define strategies in which the expectations and goals of fishermen and managers converge. The IFM assessment framework presented is aimed at assessing the interactions between management objectives, system complexity, and institutional structures. In a case study of the fishery for haddock *Melanogrammus aeglefinus* off southwest Nova Scotia details of the marine ecosystem and the economic, sociocultural, and management regimes are outlined and then incorporated into a dynamic model. Various management options are explored in response to reducing the effects of the particularly strong oscillatory behaviour in the recruitment of haddock to the fishery. From the results it can be concluded that the current institutional structures of management exacerbate the oscillations by introducing time delays into the systems. A truly effective management regime for this resource can only arise, therefore, through realignment of behaviours and expectations into a unified regime." [Abstract]

Muthukude, P.; Novak, J.L. and Jolly, C. 1991. A goal programming evaluation of fisheries development plans for Sri Lanka's coastal fishing fleet, 1988-1991. Fisheries Research; Vol. 12, No. 4, pp. 325-339. [Ministry of Fisheries and Aquatic Resources, Colombo, Sri Lanka]

"Most fisheries planning targets of the Government of Sri Lanka have been underachieved. The ad hoc nature of selecting targets and resource allocations has been cited as a major reason for this underachievement. The primary reason for the arbitrary selection of targets is the lack of survey research. Given this constraint, planners must analyze as many different alternative plans as possible and then choose the best one. In addition, goal comparisons often cannot be made using a common unit of measure, for example rupees (Rs.) allocated for subsidy versus hours of training for crew members. To assist planners in analyzing alternative plans, while accounting for sometimes conflicting objectives, goal programming was used to optimize the achievement of Sri Lanka's fisheries development targets for the planning period 1988-1991. The plan that most closely achieved planning targets favored a suspension of subsidy programs and the introduction of an 80% loan on boats and engines. The results also showed that a 20% subsidy on inboard and outboard boat hulls and engines, 20% on purchasing engines for non-mechanized traditional boats and 50% on the purchase of non-mechanized traditional boats met or exceeded planned targets." [Abstract]

Padilla, J.E.; Silvestre, G. and Dalusung, M. 1995. Bioeconomic Stress Indicators for Fisheries: Conceptual Exposition and Preliminary Applications. In: Juinio-Menez, M.A. and Newkirk, G.F. (editors). Philippine Coastal Resources Under Stress: Selected papers from the Fourth Annual Common Property Conference held in Manila, Philippines, June 16-19, 1993. Coastal Resources Research Network, Dalhousie University, Halifax, Canada and Marine Science Institute, University of the Philippines, Quezon City, Philippines.

"This paper proposes a framework for identifying stress indicators in a fishery within the context of demographic, technological and socioeconomic changes. Bio-economic derivations of a fishery supply model embodying such changes combined with an assumed demand for fish enable the identification of possible indicators of stress on the fishery resource. Stress indicators directly derived from the supply-demand model are those pertaining to catch or output, price, catch-per-unit-effort, employment and investments while those indirectly following from the model pertain to stock biomass, labor and capital productivity, and income distribution. The qualitative behaviour of these indicators under conditions typical of many fisheries in tropical developing countries are discussed. A very preliminary verification of these indicators is performed using data from selected fisheries in the Philippines and Thailand. Directions for future research are also discussed." [Abstract]

Pollnac, R.B. (editor). 1989. Monitoring and Evaluating the Impacts of Small-Scale Fishery Projects. International Center for Marine Resource Development, University of Rhode Island, Kingston, Rhode Island, United States.

"The nine chapters in this volume examine an important range of issues associated with fishery project impact monitoring and evaluation. The chapters cover a diversity of project types in locations ranging from the Caribbean and Latin America to Africa and Southeast Asia. Various issues are raised in the different chapters, but some issues reappear throughout the book. Both the diversity and communality of the studies in this volume should be of interest to those involved in the difficult process of fishery project impact monitoring and evaluation." [from Introduction]

Satia, B.P. and Hansen, L.S. 1994. Sustainability of Development and Management Actions in Two Community Fisheries Centres in the Gambia. IDAF Technical Report. Food and Agricultural Organization of the United Nations, Cotonou, Benin.

Smith, I.R. 1979. A Research Framework for Traditional Fisheries. ICLARM Studies and Reviews No. 2. International Center for Living Aquatic Resources Management, Manila, Philippines.

"A primary purpose of this monograph is to identify those areas of traditional fisheries research which have the greatest potential for contributing to the solution of problems facing traditional fishermen and their communities. To achieve this purpose, the monograph draws on both theoretical and empirical considerations available in the widely scattered literature of traditional fisheries. Following an overview which examines the goals and potentially conflicting objectives of development, a categorization of problems of traditional fisheries as either empirical or suppositional is proposed. The former involves the concrete difficulties facing fishermen such as limited 'open-access' resources, inadequate vessels and gear, lack of market power, lack of alterna-

tive income sources, and inflation. The latter, on the other hand, involves the assumptions that decision makers bring to bear on matters of development policy, planning, and research. It is argued that fishermen and fishing community oriented perspectives are essential to understanding the problems and prospects of development in this sector." [from Preface]

Solorzano, R.; de Camino, R.; Woodward, R.; Tosi, J.; Watson, V.; Vasquez, A.; Villalobos, C.; Jimenez, J.; Repetto, R. and Cruz, W. 1991. Accounts Overdue: Natural Resource Depreciation in Costa Rica. Tropical Science Center, San Jose, Costa Rica and World Resources Institute, Washington, DC, United States.

This report derives natural resource accounts for forests, soil, fisheries, mangroves and coastal resources in Costa Rica, focusing on changes in resource status over the period 1970 to 1989 (analogous to indicators of sustainability). Documentation of natural resource losses shows that, while the traditional national income accounting framework indicates an increasing national agricultural product, in fact the recent trend was dramatically downward when natural resource depreciation was taken into account.

United Nations Industrial Development Organization. 1987. Industrial Development Strategies for Fishery Systems in Developing Countries, Volume 1. Sectoral Studies Series, No. 32. Sectoral Studies Branch, Studies and Research Division, United Nations Industrial Development Organization.

"The present UNIDO study, prepared in close co-operation with FAO, provides an assessment of and strategy design for the development of the industrial system related to the fisheries sector of the 64 developing countries. The study is based on a rigorous and consistent framework whereby the fisheries sector is analyzed as a system of integrated components. In doing so, it recognizes the fisheries sector's important contribution to national, economic, social and institutional goals as well as the potential conflicts in meeting such multiple objectives.

Starting from the basic concept of a fisheries sector as an integrated system and the definition of a fisheries industrial system (FIS) countries are characterized, specific development patterns are identified, strategies and their consequent actions determined, and investment opportunities and technical assistance options revealed. In the process, a host of propositions are presented for discussion about the various economic, technical, and political components of a fisheries industrial system." [from Executive Summary]

2.2 Coastal Zone and Watershed Systems

Anonymous. 1993. Sustainable Development of Small Island Developing States. United Nations General Assembly Report A/CONF.167/PC/10, August 12, 1993.

Barbier, E.B. 1993. Sustainable use of wetlands. Valuing tropical wetland benefits: economic methodologies and applications. The Geographic Journal; Vol. 159, No. 1,

pp. 22-32. [London Environmental Economics Center, International Institute For Environment and Development, London, United Kingdom]

"Tropical wetlands are increasingly disappearing as the result of development decisions. Common examples are the conversion of mangrove swamps to fishponds, diverting water away from river floodplains, draining wetlands for agriculture and other land uses, and over-loading wetlands with pollution. Too often, such development decisions are taken without considering the loss in wetland benefits arising from damages and conversion; the underlying assumption is often that the net benefits to society of any development option must presumably be greater. However, there is much evidence to suggest that this assumption is not always correct. Many tropical wetlands are being directly exploited, often through non-market, 'informal' economic activity to support human livelihoods, e.g. through fishing, hunting, fuelwood extraction and water supply. Some of the ecological functions of wetlands, such as flood control, storm prevention and groundwater recharge, may provide even wider benefits through protection or support of economic activity and property. Finally, some wetlands comprise unique natural environments and habitats, which are of considerable value. The basic methodology for assessing and valuing the economic benefits of tropical wetlands is relatively straightforward, but difficult to apply because of data and resource constraints. Preliminary applications in Central America suggest the importance of ranking wetland characteristics and distinguishing between direct-use values, indirect-use values and non-use values. A further application in a Nigerian floodplain shows how calculation of a few direct-use values alone - for agriculture, fuelwood, and fishing - demonstrates that wetland benefits are significant, particularly when contrasted with the benefits from irrigation projects that are diverting water away from the floodplain. The analysis shows that sustainable use of the floodplain can yield sustainable economic returns to local inhabitants, and these benefits should not be excluded as an opportunity cost of any scheme that diverts water away from the wetland system. Finally, a case study of a mangrove system in Indonesia illustrates how the degree of 'environmental linkages' between the components of the system are critical in determining the extent to which the mangrove forest can be exploited for woodchip production." [from Abstract]

Bartlett, W. 1995. The Report of the Partnership on Sustainable Coastal Communities and Marine Ecosystems in Newfoundland and Labrador. Newfoundland and Labrador Round Table on the Environment and Economy and the National Round Table on the Environment and the Economy, St. John's, Newfoundland, Canada.

"The collapse of the cod fishery off the coast of Newfoundland and Labrador is a classic example of unsustainable development. The impacts and implications on an ecosystem, on an economy, and on a way of life never seem to stop. In the fall of 1994, both the National Round Table on the Environment and the Economy (NREE) and the Newfoundland and Labrador Round Table on the Environment and the Economy (NLRTEE) decided to collaborate on a project that would look at the fish

crisis from the perspective of the sustainability of coastal communities and marine ecosystems in Newfoundland and Labrador." [from Preface]

Caddy, J.F. and Griffiths, R.C. 1995. Living marine resources and their sustainable development: some environmental and institutional perspectives. FAO Fisheries Technical Paper, No. 353. Food and Agricultural Organization of the United Nations, Rome, Italy. [Marine Resources Service, FAO Fisheries Department, Rome, Italy]

"This document provides a broad perspective on issues related to living marine resources, their environment and management in the post-UNCED context provided by Agenda 21 and the Cancun Conference. The document begins with a sectorial discussion of sustainable development of living resources of nearshore and estuarine, semi-enclosed seas, coastal and shelf waters, the high seas, and Antarctic waters. Constraints on harvesting, impacts of marine pollution, and potentials for further development of resources are addressed. Each section concludes with a discussion of elements that can be included in a programme for addressing resource management, and provides a list of references on key literature related to the themes discussed, and a series of annexes which provide a glossary of key concepts, list of acronyms, list of fisheries commissions, International Organizations concerned with marine affairs, excerpts from conventions and other international agreements relating to living marine resources and their environment." [Abstract]

Charles, A.T. 1995. Sustainability Assessment and Bio-Socio-Economic Analysis: Tools for Integrated Coastal Development. In: M.A. Juinio-Menez and G.F. Newkirk (editors). Philippine Coastal Resources Under Stress. Selected papers from the Fourth Annual Common Property Conference held in Manila, Philippines, June 16-19, 1993. Coastal Resources Research Network, Dalhousie University, Halifax, Nova Scotia, Canada and Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines. [Department of Finance and Management Science, Saint Mary's University, Halifax, Nova Scotia, Canada]

"Sustainable development is particularly challenging in coastal systems, where the natural dynamics of the marine ecosystem are closely interconnected with the human dynamics of those living in the coastal zone. In pursuing integrated coastal development, one must be able to assess the current level of sustainability, and to predict future changes. To this end, this paper presents (i) a framework for joint assessment of ecological, socioeconomic, and community and institutional sustainability, and (ii) a 'bio-socio-economic' approach to quantifying and modelling the joint natural and human dynamics of sustainability. To illustrate the approach of bio-socio-economic modelling, an example is provided of labor and livelihood transition dynamics, describing shifts between fishing and aquaculture within the coastal zone." [Abstract]

Colt, A.B. 1994. The First Step in Comprehensively Evaluating Implementation of an Integrated Estuarine Management Plan: Developing Evaluation Criteria. Ocean and Coastal Management; Vol. 24, pp. 85-108. [Department of Urban and Environmental Policy, Tufts University, Medford, Massachusetts, United States]

"This paper defines and develops evaluation criteria for selected portions of the Buzzards Bay Comprehensive Conservation and Management Plan (BBCMP). This evaluative analysis identifies the types of guidance needed for implementing the BBCMP and evaluating the outcomes of that implementation. Thus the paper demonstrates the initial steps in a comprehensive evaluation of the development and implementation of a comprehensive coastal management plan. A central conclusion of this analysis is that the BBCMP's goals, objectives and recommended actions lack the specificity needed to guide its implementation and structure useful evaluations." [Abstract]

Costanza, R.; Farber, S.C. and Maxwell, J. 1989. Valuation and Management of Wetland Ecosystems. Ecological Economics; Vol. 1, pp. 335-361. [Center for Environmental and Estuarine Studies, University of Maryland, Solomons, Maryland, United States]

"We recently completed a study of wetland values in coastal Louisiana that employed both willingness-to-pay and energy analysis-based methodologies and were able to bracket a range of values within which we feel fairly confident the true value lies. However, a large amount of uncertainty remains. Our current estimates of the total present value of an *average* acre of natural wetlands in Louisiana are US $2429-6400 per acre (assuming an 8% discount rate) to $8977-17000 per acre (assuming a 3% discount rate). At the lowest value, the current annual rate of loss of Louisiana wetlands (50 sq miles per year) is worth about $77 million. At the largest value it is worth about $544 million.

In this paper we (a) discuss the fundamental theoretical and practical problems underlying natural resource valuation; (b) summarize our methods and findings for Louisiana wetlands; and (c) elaborate on some of the more recalcitrant problems attending applied natural resource valuation, including discounting and dealing with uncertainty and imprecision.

The discount rate makes more difference in the final result than any other one factor, and yet there is much disagreement about the appropriate approach to discounting natural resources. We discuss the discounting problem as applied to natural resources and argue for lower discount rates for valuing renewable natural resources than apply for other aspects of the economy.

It now seems clear that no reasonable amount of effort will produce very precise estimates of wetland values, and we suspect this is also the case for several other classes of natural resources. We elaborate a Wetlands Assurance Bonding system to address these problems." [Abstract]

De-Albuquerque, K. and McElroy, J.L. 1992. Caribbean small-island tourism styles and sustainable strategies. Environmental Management; Vol. 16, No. 5, pp. 619-632. [Department of Sociology and Anthropology, College of Charleston, Charleston, South Carolina, United States]

"This article focuses on developing a sustainable tourism in small Caribbean islands, defined here as those that have populations of fewer than 500,000. Such islands share a very fragile ecology and a high dependence on tourism. They differ in their degree of tourist penetration and visitor density and the related degree of environmental degradation.

To explain the link between tourism intensity and ecological vulnerability, the so-called 'destination life-cycle model' is presented. This suggests that islands pass through three primary stages of tourist development: low-density exploration, rapid growth and consolidation, and high-density maturation involving the substitution of man-made for natural attractions.

A broad empirical test of the model is performed through a quantitative examination of the tourism characteristics and visitor densities of a cross section of 23 small Caribbean islands. The three basic stages or tourism styles are identified: low-impact emerging areas, high-density mass-market mature destinations and rapidly growing intermediate islands in between. Some broad strategies consistent with the systems framework for a sustainable tourism with moderate densities are briefly explored." [Abstract]

Dixon, J.A. 1993. Economic benefits of marine protected areas. Oceanus; Vol. 36, No. 3, pp. 35-40.

"Marine protected areas contain valuable economic resources important to local and national economies. Careful management can allow both protection of biodiversity and economic development. Indeed, it is obvious that, rather than selecting the extremes of strict preservation or unmanaged development, balanced use of these resources for both economic and ecological functions is central to their sustainable management.

Economic benefits of marine protected areas (MPAs) include job creation through harvest of renewable and nonrenewable resources such as fish and shells, and through use of MPAs for nonconsumptive activities such as tourism and recreation. Some MPA benefits are difficult to express in monetary terms; examples include the economic value of biological resources and 'environmental services' such as wave-buffering by healthy reefs. Other benefits are easier to calculate in dollar terms: a prime example is the direct financial benefit to local economies from recreational and other activities centered on MPAs." [from article]

Dixon, J.A.; Scura, L.F. and Van'-t-Hof, T. 1993. Meeting ecological and economic goals: Marine parks in the Caribbean. Ambio; Vol. 22, No. 2-3, pp. 117-125.

"Marine parks are increasingly being established to protect endangered marine ecosystems and the biological diversity that they support. Trade-offs exist between protection and use, however, and ways must be found to produce economic benefits from marine areas while still yielding protection benefits, a question of particular importance to poorer countries that can ill afford to forego development benefits by enforcing strict protection measures. This paper examines these issues in the context of Caribbean marine parks. A number of countries that have established marine protected areas also rely on ocean-based tourism as an important, sometimes central, component of their economy. Can protection and direct use be compatible? Bonaire Marine Park is examined in some detail and monetary estimates are presented. Initial results indicate that proper management can yield both protection and development benefits but questions of ecosystem carrying capacity and national retention of revenues raise important issues for longer term sustainability." [Abstract]

Folke, C. 1991. The Societal Value of Wetland Life-Support. In: C. Folke and T. Kaberger (editors). Linking the Natural Environment and the Economy: Essays From the Eco-Eco Group. Kluwer Academic Publishers, Dordrecht, The Netherlands. [Department of Systems Ecology, Stockholm University, Stockholm, Sweden]

"In this chapter I analyse the societal value of a Swedish wetland system with respect to the various economic functions such as cleansing nutrients and pollutants, maintaining the level and quality of the drinking water, processing sewage, serving as a filter to coastal waters, sustaining genetic diversity and preserving endangered species. The major part of such life-support functions have been lost due to extensive exploitation. I evaluate the loss in terms of the reduced solar energy fixing ability (Gross Primary Production, GPP) and the deterioration of the stored peat, and compare it to the cost of replacing these environmental functions with technical processes, estimated in monetary terms and industrial energy terms. Such substitutes include irrigation dams, water transportation, well-drilling, water purification, sewage treatment plants, fertilizers, fish farming, and efforts to save endangered species. I find that the undiscounted annual monetary replacement cost is of the order 2.5 to 7 million Swedish crowns (US $0.4-1.1 million), and that the annual industrial energy cost between 15 and 50 TJ approaches the annual loss of GPP of 55 to 75 TJ, when both are expressed in units of the mm energy quality (fossil fuel equivalents). The major part of the technical replacements concerns biogeochemical processes and the hydrological cycle. Not more than about 10 per cent are related to the biological part of the wetland system. The present biophysical analysis serves as an indicator of the true life support value of a wetland system, and is thus a useful complement to economic analysis. It is concluded that ecosystems perform a lot of valuable and necessary work at no cost, and that industrial technologies should be developed to supplement and enhance this support instead of having to replace it when it has already been destroyed." [Abstract]

Gren, I.M.; Folke, C.; Turner, K. and Bateman, I. 1994. Primary and secondary values of wetland ecosystems. Environmental Resource Economics; Vol. 4, No. 1, pp. 55-74. [Royal Swedish Academy of Science, Stockholm, Sweden]

"Wetlands are continuously degraded in many parts of the world. One reason is the lack of the appropriate valuation of the multifunctionality of wetland. In an attempt to improve the understanding of the importance of this feature of wetlands an alternative classification of values is suggested; primary and secondary values. Primary value refers to the development and maintenance of ecosystems - their self-organizing capacity. Secondary values are defined as the outputs, life-support functions and services, generated by wetlands. Methods for measuring these values are discussed. Three case studies are presented which use different valuation methods and which to different degrees capture the primary and secondary values. It is concluded that only part of the total wetland value can be captured in monetary terms." [Abstract]

Griffith, M.D. and Ashe, J. 1993. Sustainable Development of Coastal and Marine Areas in Small Island Developing States: A Basis for Integrated Coastal Management. Ocean and Coastal Management; Vol. 21, No. 1-3, pp. 269-284. [Ministry of Labor, Consumer Affairs and the Environment, Christ Church, Barbados]

"...the concern about global climate change and the prospect of accelerated sea level rise and its potential impacts, particularly on low-lying coastal areas and small islands, has focused renewed attention on integrated management and planning of coastal areas as a framework within which coastal states can formulate response options to adapt to and/or mitigate climate change. The importance of this is exemplified in the convocation by the Intergovernmental Panel on Climate Change (IPCC) of a Coastal Zone Management Subgroup (CZMS) of the Response Strategies Working Group. As part of its future programming the CZMS has as an important element of its activities the support for coastal zone management (CZM) planning and the assistance to coastal countries for the development of integrated coastal management plans by the year 2000." [from Introduction]

Hartig, P.D.; Hartig, J.H.; Lesh, D.R.; Lowrie, D.G. and Wever, G.H. 1996. Practical Application of Sustainable Development in Decision-Making Processes in the Great Lakes Basin. Int. J. Sustain. Dev. World Ecol.; Vol. 3, No. 1, pp. 31-47. [Downriver Center for Environment and Development, Trenton, Michigan]

Hilton, M.J. and Manning, S.S. 1995. Conversion of Coastal Habitats in Singapore: Indications of Unsustainable Development. Environmental Conservation; Vol. 22, No. 4, pp. 307-322. [Department of Geography, University of Otago, Dunedin, New Zealand]

"...this paper aims to:
(1) Assess the extent and severity of human modification of mangrove, coral reef, and intertidal sand/mud eco-complexes in Singapore in the period 1951-93;
(2) Identify the causes of environmental change;
(3) Evaluate the implications for the remaining areas of mangrove, coral reef, and intertidal sand-and mud-flats of development proposed in the Government's Master Plan for Singapore;
(4) Examine the Government's proposals for nature conservation in Singapore as outlined in the Singapore Green Plan; and
(5) Evaluate the role of Government policy in the loss and modification of coastal ecosystems, and assess Singapore's commitment to ecological sustainability and sustainable development." [from Introduction]

Holland, M.M. 1996. Ensuring sustainability of natural resources: focus on institutional arrangements. Canadian Journal of Fisheries and Aquatic Sciences; Vol. 53 (Supplement 1), pp. 432-439. [Department of Biology, University of Mississippi, Mississippi, United States]

"Sustainable management of regions and watersheds presents a quandary. Because of the large scale of regions and of the environmental problems associated with them, sustainable management is best directed by an entity with a large purview. However, experience suggests that effective and efficient solutions to environmental problems are best developed by involving natural and social scientists possessing knowledge of fundamental principles in their respective disciplines with local stakeholders who understand both the local resources and the users of those resources. The last decade has seen a shift toward consideration of the 'human dimensions' of natural resource management. Nearly 20 years ago, a mechanism was created in Massachusetts to provide advice on sustainability of water resources: the reasons for the success of that mechanism are worth examining today. Through the creation of a Citizens Advisory Committee, there was agreement among scientists, managers, planners, and policymakers to adopt a landscape perspective, using natural rather than political boundaries in setting management goals as well as for development of the institutional arrangements necessary for management of ecological systems." [Abstract]

Institute for Research on Environment and the Economy (editors). 1992. Ecological Economics: Emergence of a New Development Paradigm. Proceedings of a Workshop. Institute for Research on Environment and Economy, University of Ottawa, Ottawa, Ontario, Canada.

The contents of this work include the rapporteur's report and six papers. The papers are the following: 1) Basic Principles and Evolution of Ecological Economics; 2) Natural Capital in Relation to Regional/Global Concepts of Carrying Capacity; 3) Application of Ecological Economics to Development: the Institutional Dimension;

4) Environmental and Resource Accounting in Developing Countries; 5) An Ecological Economics Framework for Coastal Zone Management: a Case Study of Mangrove Protection in South East Asia; 6) 200 Years of Natural Capital Erosion: A Case Study of Human Stress on the Great Lakes Ecosystem.

Jacobs, J.W. 1994. Toward sustainability in lower Mekong River Basin development. Water International; Vol. 19, No. 1, pp. 43-51. [Department of Geography, National University Singapore, Kent Ridge, Singapore]

"The lower Mekong River Basin of Southeast Asia is at an important juncture in its path of development. The natural resource base upon which future development will depend is being undermined by deforestation. Poverty in many places in the basin provides few options other than continued use of the forests for fuelwood, slash-and-burn agriculture, as well as commercial uses. The Mekong River holds great potential in helping meet the region's energy and food requirements, especially given the low level of water development in the basin. It is generally accepted that any development program must account for a range of socioeconomic, cultural and environmental factors. The record of water development projects in the basin holds clues about their strengths and weaknesses in promoting environmentally- and socially-responsible development. Reviewing past work also shows how the emphasis of water development programmes has changed during the past two to three decades. A review of the contemporary work program of the Mekong Committee and Secretariat reflects the extent to which they have learned such lessons and, in turn, their potential for contributing to more sustainable development in the basin." [Abstract]

Jansson, AM. and Jansson, B.-O. 1988. Energy Analysis Approach to Ecosystem Redevelopment in the Baltic Sea and Great Lakes. Ambio; Vol. 17, No. 2, pp. 131-136. [Askoe Laboratory, University of Stockholm, Stockholm, Sweden]

"The environmental degradation of large lakes and coastal seas shows similar disturbance patterns which calls for a common approach to redevelopment. Energy analysis sensu H.T. Odum is proposed as a tool to understand and quantify processes in ecological and economic systems and their interrelationships. It facilitates the design of management strategies that with moderate expenditures of energy and capital for the human society takes greatest possible advantage of Nature's own capacity for rehabilitation." [from Abstract]

Juhasz, F. 1991. An International Comparison of Sustainable Coastal Zone Management Policies. Marine Pollution Bulletin; Vol. 23, pp. 595-602. [Environment Directorate, Organization of Economic Co-Operation and Development, Paris, France]

"Management of coastal resources includes a combination of sectoral and environmental policies. To implement a successful sustainable policy in any coastal

region and for the country as a whole a high degree of integration between development and environment policies is an essential prerequisite. OECD governments at all levels, including at the international level, recognise the need for integration, but improvements in sustainable coastal resource management, i.e. maintaining the quality and quantity of the services flowing from coastal resources, have been limited. This paper examines, on the basis of certain criteria, the performance of OECD countries in coastal zone management and suggests measures to improve integration with the aim of promoting sustainable management of coastal resources." [Abstract]

Kiflemariam, M. 1995. Management of Coastal Ecosystems and Development Needs: An Alternative Option. In: Coastal Systems and Sustainable Development in Africa. Proceedings of a UNESCO Regional Seminar on Human Impacts on Coastal Ecosystems, their Response and Management Problems, ROSTA, Nairobi, 5-9 April 1993. UNESCO Reports in Marine Science, No. 66. United Nations Educational, Scientific, and Cultural Organization, Paris, France. [Department of Biology, Addis Ababa University, Addis Ababa, Ethiopia]

"Coastal ecosystems, subsystems and resource units are under the direct influence of two different but naturally interlinked environments, i.e. terrestrial and aquatic. They are exceptionally fragile although their potential could be of utmost importance for various development purposes. Africa's coastal zones are comparatively smooth and with lower concentration of continental shelves. A lot of African Maritime countries are facing the adverse consequences of natural and artificial factors, despite the fact that various marine resources of coastal ecosystems could contribute to their nutritional, industrial, educational, and recreational needs. A modest attempt was made to assess the roles that these coastal systems have in development and the problems of coastal zone management with particular reference to the Red Sea coastal systems. Schematic models depicting human ecology, the coastal system, an ideal system of development and relative coastal health were used. Emphasis rests upon the incorporation of ecological and conservation principles so that development could be sustained based on multipurpose objectives and moves." [Abstract]

Krysanova, V. and Kaganovich, I. 1994. Modeling of Ecological and Economic Systems at the Watershed Scale for Sustainable Development. In: A-M. Jansson, M. Hammer, C. Folke, and R. Costanza (editors). Investing in Natural Capital - The Ecological Economics Approach to Sustainable Development. Island Press, Washington, DC, United States. [Institute of Economics, Estonian Academy of Sciences, Tallinn, Estonia]

"Interrelations between ecological and economic systems and the possibility of their sustainable development can be analyzed by computer models. Relatively large watersheds, with their natural boundaries, provide a convenient framework to investigate effects of human activities on ecosystems through simulation modeling. Such models may be used for estimating the productive capacity of renewable resources and

various strategies of reuse to determine how to manage water and land resources for ecologically sustainable development.

Several approaches are proposed for watershed modeling in an ecological economic framework: (1) combining of economic and ecological models, ecologization of Leontiev-type input-output models, and simulation modeling of watershed loading with economic evaluation. Historical analysis is important for comparing past and current management items and for estimating the rates of important processes. Analysis in the simulation modeling framework reveals the close interdependence between ecological and economic components of the watershed system and the significant economic dependence of human societies on natural capital." [Abstract]

Lamson, C. 1986. Planning for Resilient Coastal Communities: Lessons from Ecological Systems Theory. Coastal Zone Management Journal; Vol. 13, No. 3-4, pp. 265-280. [Dalhousie Ocean Studies Programme, Dalhousie University, Halifax, Nova Scotia, Canada]

"One of the least understood aspects of coastal zone utilization is how communities respond and adapt to changes occuring in the marine environment and to changes which transform the socioeconomic, political, and administrative environment of the coastal zone. In Atlantic Canada, it is estimated that there are some 1,300 'fishing communities,' yet these communities vary considerably in terms of population size, proximity to urban centers, and dependence upon the local resource base to provide employment opportunities and alternatives. Although numerous government planning documents have purported to support 'community revitalization' and 'self-sufficiency/ self-reliance,' few inquiries have been directed towards ascertaining how many communities have maintained resiliency in the face of unexpected and sudden shock, or have adapted to more gradual change. This essay argues that human communities and ecological systems may have similar attributes, and that appropriate resource development and management planning should take account of these traits as well as the sustaining structural support mechanisms." [Abstract]

McEachern, J. and Towle, E.L. 1974. Ecological Guidelines for Island Development. IUCN Publications New Series, No. 30. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland.

This book begins with an introduction to the island system, defining it and outlining the biocybernetic model. Then the concept of development is discussed in context of the island system. Insular land-use activities and their implications for the environmental, aesthetic, ecological, and cultural values of the system are discussed. In conclusion, guidelines for minimizing some adverse development impacts and enhancing certain resources are outlined.

Mitchell, B.D. and de Silva, S.S. 1992. Sustainable Utilization of Inland Water Resources: An Integrated Program for Research and Management. NAGA, The ICLARM Quarterly; Vol. 15, No. 2, pp. 14-17. [Faculty of Aquatic Science, Deakin University, Warrnambool, Victoria, Australia]

"In both developed and developing countries, there is increased competition for water resources, resulting in deficiencies in supply and in various forms of pollution. In developing countries, the nutritional potential of aquatic resources is very important. To realize this potential, integrated research and management for sustainable water resource use are needed." An interdisciplinary framework for research and resource development in aquatic ecosystems is outlined, using a flowchart to depict the phases involved, and to list relevant variables (indicators) requiring study, relating to Land, Water Quality and Quantity, Community Structure and Function, Exploitation, etc.

Moffat, D. and Linden, O. 1995. Perception and Reality: Assessing Priorities for Sustainable Development. Ambio; Vol. 24, No. 7-8, pp. 527-538.

"The Niger Delta is the richest part of Nigeria in terms of natural resources. The area has large oil and gas deposits, as well as extensive forests, good agricultural land and abundant fish resources. Despite the tremendous natural and human resource base, the region's potential for sustainable development remains unfulfilled and its future is being threatened by environmental degradation and deteriorating economic conditions which are not being addressed by present policies and actions. Twenty-five years of oil development have not brought significant benefits to the region. Resource-use decisions are being driven by a lack of development, poor health, stagnant agricultural productivity, very limited opportunities in urban areas, rapid population growth, and tenuous property rights. The article attempts to advance beyond the prevailing emotive arguments on the causes of environmental degradation by examining the full range of environmental issues to determine priorities and to suggest options for sustainable development within an integrated coastal zone management framework." [Abstract]

Nieto, H.P. 1993. Linking Territorial and Coastal Planning: the Venezuelan Experience. Ocean and Coastal Management; Vol. 21, pp. 227-243. [Comision Nacional de Oceanologia (CNO) de Venezuela Conicit, Caracas, Venezuela]

"Venezuela is located in central northern South America, with some 4,000 km of coastline and near 700,000 km^2 of marine and submarine areas. The Venezuelan coastal zone is characterized by serious problems of land use and utilization of its natural resources, caused by a generally anarchial spatial occupation and lack of sufficient legal and administrative means for control. In this paper, a synthesis of the Venezuelan approach to attaining a sustainable development of its marine and coastal zones is presented. This means the accomplishment of the social and economic development of the Venezuelan population in general, and specifically the inhabitants,

taking into account the legal and administrative patterns that govern land use planning and the utilisation of its natural resources, particularly in marine and coastal areas. The paper is organised in three parts: (1) the diagnosis of the current situation; (2) the presentation of a hypothesis based on present trends (trend scenario); and (3) the statement and application of a sound and adequate solution (desirable and possible scenario)." [Abstract]

Rosier, J.; Hill, G. and Kozlowski, J. 1986. Environmental Limitations: A Framework for Development on Heron Island, Great Barrier Reef. Journal of Environmental Management; Vol. 23, No. 1, pp. 59-73. [Regional and Town Planning Department, University of Queensland, St. Lucia, Australia]

"Sustainable development of tourism or recreation facilities/activities in a sensitive environment requires that ecological limits of the environment are not exceeded. Spatial analysis of the interrelationship between natural resources and development is necessary if decisions about the location of the development are to be based on ecological criteria. The Ultimate Environmental Threshold (UET) method was developed as a means of identifying areas, development levels and time periods to which various forms of tourism/recreation should be confined. The application of the method on Heron Island concentrated on identifying areas from which, ideally, development should have been excluded when the island was first developed. The present state of these idealized exclusion zones was assessed to determine the consequences and management implications of development exceeding the environmental limitations." [Abstract]

Ruitenbeek, H.J. 1992. Mangrove Management: An Economic Analysis of Management Options with a Focus on Bintuni Bay, Irian Jaya. Environmental Management Development in Indonesia Project (EMDI), EMDI Environmental Reports, 8. Ministry of State for Population and Environment, Government of Indonesia, Jakarta, Indonesia and School for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia, Canada. [H.J. Ruitenbeek Resource Consulting Ltd., Ottawa, Ontario, Canada]

"Woodchip exports pose a potential threat to a 300,000 ha mangrove ecosystem in the Bintuni Bay area of Irian Jaya, Indonesia. The bay supports an important shrimp export industry, and coastal areas support 3000 households. Traditional uses of mangroves have an estimated value of Rp20 billion/yr (US$10 million/yr); fisheries are valued at Rp70 billion/yr (US$35 million/yr) and selective mangrove cutting schemes have a maximum value of Rp40 billion/yr (US$20 million/yr).

Forest management options, ranging from clear cutting to a cutting ban, are evaluated in a cost benefit analysis incorporating linkages between mangrove conversion, offshore fishery productivity, traditional uses, and benefits of erosion control and biodiversity maintenance functions. 'Linkage scenarios' are developed which reflect potential ecosystem component interactions in Bintuni Bay. Clear cutting is optimal

only if linkages are ignored. A cutting ban is optimal if linear and immediate linkages between ecosystem components exist. Under a scenario with linear but delayed linkages of 5 years, selective cutting of 25% of the harvestable mangrove is the optimal strategy; it has a present value of Rp70 billion (US$35 million) greater than the clear cutting option, Rp3 billion (US$1.5 million) greater than the cutting ban option, and more extensive cutting would yield no additional net benefits.

Strong economic arguments exist for conservative mangrove clearing. Where strong ecological linkages occur, severe restrictions on clearing activities will be economically optimal. Where ecosystem dynamics are uncertain, programs reducing linkage effects - such as greenbelts, replanting, or selective cutting - will minimize potential economic losses." [Abstract]

Sadler, B. 1990. Sustainable Development and Water Resource Management. Alternatives; Vol. 17, No. 3, pp. 14-19. [Institute for the North American West, Victoria, British Columbia, Canada]

"The focus of this article is on evaluating the contributions that sustainability concepts can make to the theory and practise of water resource management. The emerging model will then be compared to prevailing approaches in water-resource policy making, river basin planning, and hydro development." [from article]

Singh, N.C. 1992. Sustainable Development - Its Meaning for the Caribbean. Social and Economic Studies; Vol. 41, No. 3, pp. 145-167.

"In order to give historical perspective to the concept and process of sustainable development, a brief review of major recent views, from the Greek to the now emerging Biospheric World View is presented. Sustainable development is presented as the pathway from the current mechanical world paradigm to the emergent biospheric view. Concepts of sustainable development are reviewed and discussed in general terms and with specific reference to the Caribbean. Approaches at operationalising the concept at the global level and in the Caribbean region are summarised. An attempt is made at laying the foundations of an integrated academic discipline of sustainable development." [from Abstract]

Turner, R.K.; Doktor, P. and Adger, N. 1994. Sea-Level Rise and Coastal Wetlands in the U.K.: Mitigation Strategies for Sustainable Management. In: A-M. Jansson, M. Hammer, C. Folke, and R. Costanza (editors). Investing in Natural Capital - The Ecological Economics Approach to Sustainable Development. Island Press, Washington, DC, United States. [Center for Social and Economic Research on the Global Environment, University of East Anglia, Norwich, England]

"This chapter surveys a range of sustainability perspectives and applies them in the context of potential global warming, its consequences and policy responses in

coastal zones. A strong sustainability (SS) approach (underpinned by the precautionary principle) is contrasted with a weak sustainability (WS) approach (buttressed by the cost-benefit principle). It is possible to distinguish these two approaches and their preferred policy response options at both the macro and micro-policy level. At the latter level, WS requires only a 'business as usual' sea and coastal defense strategy until the level of uncertainty is reduced. SS requires that a full range of sea-level ruse mitigation options (from retreat to full protection) be appraised and that the most cost-effective option is identified.

A case study analysis, based on the East Anglian Coastal Zone (England), is outlined and the cost-benefit results are reported. The results indicate that although not all the assets at risk in the zone have been valued in economic terms, a precautionary-protection plus manage retreat-strategy is the most cost-effective option." [Abstract]

UNESCO. 1995. Coastal systems and sustainable development in Africa. Proceedings of a UNESCO Regional Seminar on Human Impacts on Coastal Ecosystems, and their Response and Management Problems, ROSTA, Nairobi, 5-9 April 1993. UNESCO Reports in Marine Science, No. 66. United Nations Educational, Scientific, and Cultural Organization, Paris, France.

"The UNESCO Regional Office for Science and Technology in Africa (ROSTA) has compiled, within this issue of UNESCO Reports in Marine Science, various scientific papers presented during the Regional Seminar on Human Impacts on Coastal Systems, their Response and Management Problems, held at ROSTA (United Nations Office, Gigiri, Nairobi, Kenya) from 5 to 9 April 1993.

The objectives of the Seminar, convened within one year of UNCED's adjournment, were inter alia: to bring together a selected group of scientists to exchange ideas and to discuss their achievements, problems, and future strategies; to recommend measures aimed at mitigating adverse human impacts in order to improve the balanced coexistence of coastal populations and marine ecosystems; to contribute to the further promotion of marine science and management of the coastal zone in the region by the publication of the Seminar's proceedings, as well as give added impetus to the objectives and relevant conclusions of UNCED." [Abstract]

UNESCO. 1992. Coastal systems studies and sustainable development: Proceedings of the COMAR Interregional Scientific Conference, UNESCO, Paris, 21-25 May 1991. Co-sponsored by: UNESCO; United Nations Environment Programme (UNEP); Scientific Committee on Oceanic Research (SCOR); International Association for Biological Oceanography (IABO). UNESCO Technical Papers in Marine Science, No. 64. United Nations Educational Scientific and Cultual Orgaization, Paris, France.

Contents: 1) Conference on coastal systems studies and sustainable development; 2) Differences among coastal systems: the controlling influences of nutrient input and the practical implications for management; 3) Human influence and evolution of the demography in the coastal zone; 4) Biological coastal communities: productivity

and impacts; 5) Marine biodiversity, sustainable development and global change; 6) River sediment discharge to the sea: new analysis of old data; 7) Mangrove forests in Pakistan; 8) Some socio-economic aspects of human communities in the mangrove area of Ngoc Hien District, Minh Hai Province; 9) Development of the natural reservation of mangroves along China Coast; 10) Human activities, environmental problems and management of the north coast of West Java, Indonesia, with emphasis on the Jakarta Bay; 11) Interdisciplinary environmental assessment of the archipelago Sabana-Camaguey (Cuba), prior to extensive tourism development projects; 12) Review and future perspectives of the COMAR-COSALC I programme on beach and coastal stability in the eastern Caribbean Islands - 1985-1991; 13) Coastal research in the south-west Atlantic Ocean; 14) The temperate coastal systems of Latin America; 15) Effects of climatic and oceanographic changes in the south-east Pacific Region: El Nino phenomenon; 16) The COMARAF Project; 17) Sandy beaches evolution and management in North Africa; 18) The coastal systems of East Africa: a mangrove ecosystem case study; 19) The North West European coastal river; 20) Ecological and social consequences of the 1989 Alaska oil spill; 21) Causes of appearance of anaerobic conditions in prebottom waters of the north-western shelf of the Black Sea; 22) Future coastal management in New Zealand/Aotearoa; 23) The Coastal Marine Project of UNESCO: COMAR. Annex 1) Coastal marine projects of UNESCO: COMAR. Annex 2) List of participants. [Contents]

Working Group on Watershed Management and Development. 1988. The Role of Watershed Management in Sustainable Development. Working Paper 3, Forestry for Sustainable Development Program. Department of Forest Resources, College of Natural Resources, University of Minnesota, St. Paul, Minnesota, United States.

"This paper has two basic purposes: 1) to explain what a watershed management framework is and how its use can contribute to the sustainability of development efforts, and 2) to suggest what types of integrated training activities are needed to ensure a wider appreciation of watershed management concepts, principles, and practices and their integration into the mainstream of development work." [from Executive Summary]

2.3 Environmental and Ecosystem Health Indicators

Bella, D.A.; Jacobs, R. and Li, H. 1994. Ecological indicators of global climate change: A research framework. Environmental Management; Vol. 18, No. 4, pp. 489-500. [Department of Civil Engineering, Oregon State University, Corvallis, Oregon, United States]

"Large-scale environmental research efforts are conducted under frameworks that provide a common basis for evaluating research in many diverse fields. Such frameworks should be subjected to critical review to determine if they meet crucial expectations. In the case of the US Global Change Research Program, we perceive that

most research follows a framework that we define as the predictive model framework. We believe this framework is insufficient for resolving the unprecedented predicaments posed by global change. We recommend a complementary framework, the system response framework, which directs research toward useful indicators of change rather than precise predictions. We further argue that, even if research is complementary and effective under the two frameworks, conclusive results prior to decisions should not be expected. The burden of proof must itself be a continuing topic of open discourse and inquiry." [Abstract]

Best, E.P.H. and Haek, J. (editors). 1982. Ecological Indicators for the Assessment of the Quality of Air, Water, Soil, and Ecosystems. Papers Presented at a Symposium held in Utrecht, October, 1982. D. Reidel Publishing Company, Dordrecht, Holland. [Limnological Institute, Nieuwersluis]

"In this issue, firstly an elucidation is given of the concept of ecological indication, and the possibilities and difficulties in the use of bio-indicators, and the problems concerning the notion of quality. In the next sections, the ecotoxicology and the ecological indication for, respectively, air, soil, water, and even more complex ecosystems, are treated. To end with, some remarks from a governmental point of view on the possibilities of bio-indication. The different papers vary greatly in their character, ranging from a short introduction or the description of a planned sampling scheme, to a more or less extensive review of the pertaining literature or a thorough research paper." [from Editorial]

Caddy, J.F. and Mahon, R. 1995. Reference points for fisheries management. FAO Fisheries Technical Paper, No. 347. Food and Agricultural Organization of the United Nations, Rome, Italy. [FAO Fisheries Department, Rome, Italy]

"This paper reviews the conceptual background and application of technical reference points in fisheries management. Two types of reference points are recognized: target reference points (TRPs) and limit reference points (LRPs). The use of maximum sustainable yield (MSY) as a target reference point is considered in the light of past performance of fisheries management, and it is suggested that MSY and other reference points formerly used as targets may be more appropriately applied as LRPs." [Abstract]

Cairns, J.Jr. and McCormick, P.V. 1992. Developing an ecosystem-based capability for ecological risk assessments. Environmental Professional; Vol. 14, No. 3, pp. 186-196. [University Center of Environmental and Hazardous Materials Studies, Virginia Polytechnical Institute and State University, Blacksburg, Virginia, United States]

Cairns, J.Jr.; McCormick, P.V. and Niederlehner, B.R. 1993. A proposed framework for developing indicators of ecosystem health. Hydrobiologia; Vol. 263, No. 1, pp. 1-44. [University Center of Environmental and Hazardous Materials Studies, Virginia Polytechnical Institute and State University, Blacksburg, Virginia, United States]

"Considerations involved in developing a suite of indicators to monitor regional environmental health, similar in conception to management use of 'leading economic indicators', are described. Linkages between human activities and well being and the state of the environment are considered essential to the evaluation of general environmental health. Biogeochemical and socioeconomic indicators are mutually affected by environmental degradation and examples of both categories of indicators are described. Desirable properties in indicators of environmental health vary with their specific management use. Different indicators are called for when collecting data to assess the adequacy of the environment, monitor trends over time, provide early warning of environmental degradation, or diagnose the cause of an existing problem. Tradeoffs between desirable characteristics, costs, and quality of information are inevitable when choosing indicators for management use. Decisions about what information to collect for which purpose can be made more rationally when available indicators are characterized and matched to management goals." [Abstract]

Cairns, J.Jr. and Niederlehner, B.R. 1995. Ecosystem Health Concepts as a Management Tool. Journal of Aquatic Ecosystem Health; Vol. 4, pp. 91-95. [Department of Biology, Virginia Polytechnic Institute & State University, Blacksburg, Virginia, U.S.]

"Arguably, no ecosystems on the planet are unaffected by human society. Airborne contaminants are circulated globally; trash is left even on Everest; and the world's oceans contain oil and plastic, not to mention a variety of other wastes from human society. However, ecosystems are more than depositories for the waste of human society. Ecosystems furnish a variety of services that benefit human society, such as maintaining the atmospheric gas balance and water quality. As the human population approaches 10 billion, the amount of space available for occupancy by non-domesticated species will have to be managed so that, at the very least, services necessary to maintain the quality of human life will not diminish and, optimally, little additional biotic impoverishment (extinction of species) occurs. From the anthropocentric viewpoint, ecosystem health could be viewed as the maintenance of biological integrity necessary for the delivery of ecosystem services necessary for human society. This manuscript discusses the barriers to the use of ecosystem health concepts, which diminish risks to natural systems and the ways in which the integrity of these systems can be maintained. Maintenance of integrity will ensure the sustainable use of these ecosystems as sources of services upon which human society is dependent." [Abstract]

Canadian Council for International Cooperation. 1992. Coastal Ecosystems, Environmental Screening of NGO Development Projects. Canadian Council for International Cooperation, Ottawa, Ontario, Canada.

"This is one in a series of booklets and associated checklists which have been prepared to assist in the environmental screening of non-governmental organization (NGO) development projects. This booklet presents methods for identifying and reducing undesirable environmental impacts in highly vulnerable coastal zones of the tropics: mangroves, coral reefs and estuaries." [from Preface]

Council of Great Lakes Managers. 1991. A proposed framework for developing indicators of ecosystem health for the Great Lakes region. Council of Great Lakes Research Managers Report to the International Joint Commission. International Joint Commission, Windsor, Ontario, Canada.

Edwards, C.J. and Reiger, H.A. (editors). 1990. An ecosystem approach to the integrity of the Great Lakes in turbulent times: proceedings of a 1988 workshop, Burlington, Ontario, June 14-16, 1988. Great Lakes Fishery Commission special publication, 90-4. [USDA Forest Service, Rhinelander, Wisconsin, United States]

GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). 1995. Biological Indicators and Their Use in the Measurement of the Condition of the Marine Environment. GESAMP Reports and Studies, No. 55. United Nations, New York, New York, United States.

"The goal of this document is to provide a general framework for appropriate application of contemporary techniques used to assess chemical, physical, and biological impacts on marine ecosystems. Our focus is broad. Consequently, an approach to assessment is described that can be used as a framework for many types of investigation. GESAMP does not consider the detailed validation or use of particular techniques; these have been satisfactorily evaluated and reviewed elsewhere, (the IOC/UNEP/IMO Group of Experts on Effects of Pollution (GEEP) workshops, Bayne et al, 1988, Addison and Clarke 1991; Stebbing et al 1992). Our approach is illustrated using examples of perturbations of marine ecosystems. Also presented are discussions of the types of impact that may be of concern in selected habitats and the range of technique that can best be used for specific perturbations. Principles of experimental design and analysis for these investigations are also described throughout the report." [from Terms of Reference]

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). 1994. Report of the twenty-fourth session of GESAMP, New York, 21-25 March 1994. GESAMP Reports and Studies, No. 53. United Nations, New York, New York, United States.

Contents include: 1) Assessment of the condition of marine environment; 2) Evaluation of the hazards of harmful substances carried by ships; 3) Indicators of marine ecosystem health; 4) Environmental impacts of coastal aquaculture; 5) The sea-surface microlayer; 6) Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* in the Black Sea; 7) Future work programme; 8) Matters of immediate or increasing concern with regard to the status of the marine environment. [Contents]

Hakanson, L. 1993. A system for lake ecosystem indices. Journal of Aquatic Ecosystem Health; Vol. 2, pp. 165-184. [Institute of Earth Sciences, Uppsala University, Uppsala, Sweden]

"There is a growing awareness of the need to develop a more rational structure for scientific decision-making in the environmental sphere. The aim of this paper is to present an outline to a system for ecosystem indices (or indicators). This work is based on a holistic ecosystem perspective and the aim is to present an overall concept rather than practical results. One of the purposes of ecosystem indices is to give politicians and the general public a more easily understandable account of the environmental status and how it changes. An ecosystem index should not only be simple and concise, scientifically relevant and practical, but also economically feasible. This approach uses several important concepts, like target organisms, target ecosystems, environmental sensitivity, and environmental cost/benefit analyses related to remedial measures. Some of the ideas brought forward in this work may be unrealistic because of the complexities involved in establishing simple, practical and meaningful ecological indices. Still, the benefits of establishing even crude environmental indicators for certain ecosystems are so great, that this path is well worth pursuing." [Abstract]

Harding, L.E. (editor). 1990. Monitoring status and trends in marine environmental quality: proceedings of a symposium in conjunction with the 17th annual aquatic toxicity workshop, Vancouver, British Columbia, November 5-8, 1990. Environment Canada, Ottawa, Ontario, Canada. [Environment Canada, Conservation and Protection, Vancouver, British Columbia, Canada]

Hart, B.T.; Campbell, I.C.; Angehrn-Bettinazzi, C. and Jones, M.J. 1993. Australian water quality guidelines: a new approach for protecting ecosystem health. Journal of Aquatic Ecosystem Health; Vol. 2, pp. 151-163. [Water Studies Center, Monash University, Melbourne, Australia]

"The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Australian Water Resources Council (AWRC) have developed a National Water Quality Management Strategy which seeks to ensure that the nation's water resources are managed on a sustainable basis. An important element of this strategy are the Australian Water Quality Guidelines which focus on the protection of

Australian freshwater and marine ecosystems. Here the aim is to protect biodiversity and maintain the ecological integrity of each marine and freshwater resource. Specific guidelines have been formulated in terms of key indicators of quality, with a single reference value or ranges of reference values provided for guidance. For those indicators where ranges are provided, it is the expectation that State environmental and resource management agencies will undertake local, site-specific investigations of their own systems to define the specific levels to be adopted. For the first time, specific and quantitative indicators have been introduced; these are species richness, species composition, primary production, and ecosystem function.

As Australia progresses towards broader, more holistic, ecologically-based management of the nation's water resources, the present water quality guidelines must be extended to ecosystem or environmental guidelines, where the maintenance of adequate water quality guidelines is seen as only one (albeit important) component. Other considerations must include habitat protection, sediment quality, and stream flow maintenance. This increased emphasis on more ecologically-focused management of Australia's inland and coastal waters will present a number of challenges for the three major groups involved: the community, the managers, and the researchers. These challenges are discussed." [Abstract]

Hartig, J.H. and Zarull, M.A. 1992. Towards defining aquatic ecosystem health for the Great Lakes. Journal of Aquatic Ecosystem Health; Vol. 1, pp. 97-107. [International Joint Commission, Windsor, Ontario, Canada]

"The Canada - US Great Lakes Water Quality Agreement defines Areas of Concern as geographic areas that fail to meet the general or specific objectives of the Great Lakes Water Quality Agreement where such failure has caused or is likely to cause impairment of beneficial use or the area's ability to support aquatic life. Impairment of beneficial use is defined by the Agreement as a change in the physical, chemical or biological integrity sufficient to cause any one of 14 designated use impairments. In 1987 the International Joint Commission's Great Lakes Water Quality Board (GLWQB) recommended that criteria be developed to determine when ecosystem conditions have been impacted enough to warrant designation as an Area of Concern and when conditions have improved sufficiently to be delisted. Based on scientific input and policy considerations, the GLWQB adopted, in principle, a set of quantitative and qualitative listing/delisting criteria for each of the 14 use impairments. These criteria can be uniformly applied throughout the basin. Further, the GLWQB recommended future refinement of these criteria based on advances in science and public input." [Abstract]

Hawkins, S.J.; Proud, S.V.; Spence, S.K. and Southward, A.J. 1993. From the individual to the community and beyond: water quality, stress indicators and key species in coastal ecosystems. In: D.W. Sutcliffe (editor). Water Quality and Stress Indicators in Marine and Freshwater Ecosystems: Linking Levels of Organization

(Individuals, Populations, Communities). Freshwater Biological Society, Ambleside, United Kingdom. [Port Erin Marine Laboratory, Isle of Mann, United Kingdom]

"This review examines water quality and stress indicators at levels of organization from the individual to the community and beyond by means of three case studies concentrating on rocky shores within the north-east Atlantic...

The discussion considers the use of bioindicators at various levels of organization. Species which are good at the cellular or individual level are not useful at the population or community level - particularly if they have a planktonic stage leading to recruitment fluctuations... The importance of monitoring recovery of perturbed systems as a means of cross-calibrating and integrating bioindicators at different levels of organization is emphasised." [from Abstract]

Hoppes, W.G. 1991. Responsible stewardship of the Lake Ontario ecosystem: quantitative indicators to monitor binational efforts. International Association for Great Lakes Research. [Niagara Frontier Program Office, Region 2]

Indicators Task Force. 1991. A Report on Canada's Progress Towards a National Set of Environmental Indicators. SOE Report, No. 91-1. State of Environment Reporting, Environment Canada, Ottawa, Ontario, Canada.

This report presents a preliminary set of environmental indicators for five separate categories, atmosphere, water, biota, land, and natural economic resources. The atmosphere indicators are used to measure climate change, stratospheric ozone depletion, radiation exposure, acid rain, and outdoor urban quality. The water indicators measure freshwater quality, toxic contaminants in the freshwater ecosystem and marine environmental quality. The indicators in the biota category are measuring biological diversity at work and the state of wildlife. Land indicators measure protected areas, urbanization and solid waste management. The natural economic resources indicators measure forestry, agriculture, fisheries, water use, and energy.

Intergovernmental Task Force on Monitoring Water Quality, Interagency Advisory Committee on Water Data, Water Information Coordination Program. 1993. Water-Quality Monitoring in the United States - 1993 Report of the Intergovernmental Task Force on Monitoring Water Quality. Contact: U.S. Geological Survey, Reston, Virginia, United States.

This report outlines the work of the Intergovernmental Task Force on Monitoring Water Quality, notably that dealing with environmental indicators, data-collection methods, data management and information sharing, assessment and reporting, groundwater monitoring, and training. Implementation of the relevant plans, and possible future activities, are also discussed.

Karr, J.R. 1981. Assessment of Biotic Integrity Using Fish Communities. Fisheries; Vol. 6, No. 6, pp. 21-27. [Department of Ecology, Ethnology, and Evolution, University of Illinois, Champaign, Illinois, United States]

"Man's activities have had profound, and usually negative, influences on freshwater fishes from the smallest streams to the largest rivers. Some negative effects are due to contaminants, while others are associated with changes in watershed hydrology, habitat modifications, and alteration of energy sources upon which the aquatic biota depends. Regrettably, past efforts to evaluate effects of man's activities on fishes have attempted to use water quality as a surrogate for more comprehensive biotic assessment. A more refined biotic assessment program is required for effective protection of freshwater fish resources. An assessment system proposed here uses a series of fish community attributes related to species composition and ecological structure to evaluate the quality of an aquatic biota. In preliminary trials this system accurately reflected the status of fish communities and the environment supporting them." [Abstract]

Keddy, P.A.; Lee, H.T. and Wisheu, I.C. 1993. Choosing Indicators of Ecosystem Integrity: Wetlands as a Model System. In: S. Woodley, J. Kay and G. Francis (editors). Ecological Integrity and the Management of Ecosystems. Published for Heritage Resources Center, University of Waterloo, and Canadian Parks Service, Ottawa, by St. Lucie Press, Delray Beach, Florida, United States. [University of Ottawa, Ottawa, Ontario, Canada]

"Our purpose here is to focus on indicators of integrity arising out of our own experiences working in wetlands. Our approach is pragmatic, in that we will accept existing definitions of integrity (e.g., Karr 1991, this volume) and list some indicators of integrity which we believe to be of value in wetlands. This list is not complete, but we believe that by starting a list, we will encourage others to contribute new indicators, and modify those already on the list. Our guiding philosophy in selecting these indicators was the belief that they should measure habitat and community state variables at a macro scale (Keddy 1991); we assume that in most cases individual species will persist if quality and diversity of habitat is maintained. The long term goal is to have an agreed upon list of indicators, with a series of constraints stating in which kinds of wetlands each indicator is appropriate, and which values of that indicator are desired. We suggest that this goal could culminate in a guidebook to wetland indicators, and suggest some steps to reach this goal." [from Introduction]

Laane, W.E.M. and Peters, J.S. 1993. Ecological objectives for management purposes: applying the Amoeba approach. Journal of Aquatic Ecosystem Health; Vol. 2, pp. 277-286. [Institute for Inland Water Management and Waste Treatment RIZA, Lelystad, The Netherlands]

"Dutch integral water management aims to restore and maintain healthy aquatic ecosystems, which can sustain most human uses. Clear ecological objectives are necessary. Sustainability of fundamental ecological values (production and yield, species diversity, and self-regulation) is assumed to be the best preserved in the reference situation. This is the situation, in which human influence is minimal.

A general method to present ecological information, the Amoeba approach is discussed. This approach uses selected species as representatives for the ecosystem. Criteria for the selection of species are discussed. For each species (target variable) the current situation, the reference situation, and estimated effects of measures can be found and plotted in an amoeba-like figure. The presentation is a simplification and is therefore easily understood by managers, politicians, and the public. It's application for some Dutch inland waters is discussed." [Abstract]

Laevastu, T. and Larkins, H.A. 1981. Marine Fisheries Ecosystem - Its Quantitative Evaluation and Management. Fishing News Books Ltd., Surrey, Great Britain. [National Marine Fishing Office, Seattle, Washington, United States]

"This book is an attempt to summarize in quantitative terms the major processes of a marine ecosystem although emphasis has been placed on the fish biota and its relation to the environment. The main purpose is, however, to describe an approach to quantitative, numerical ecosystem simulation applicable to fisheries research and management purposes. The biological and ecological aspects of various processes are described only to the extent necessary to explain their application in simulation. The principles of large-scale simulation (modeling) presented here are based on experiences derived from not only ecosystem simulation studies but also from a variety of large-scale meteorology and oceanography model studies. Large-scale simulation models use a multitude of modeling (simulation) techniques and are multipurpose, whereas models designed for special purposes tend to be simplifications of processes and conditions and often present only a caricature of one selected aspect of nature." [from Chapter 1]

Leibowitz, N.C.; Squires, L. and Baker, J.P. 1991. Environmental monitoring and assessment program: Research plan for monitoring wetland ecosystems. Ecological Research Series, U.S. Environmental Protection Agency.

Minns, C.K. 1995. Approaches to assessing and managing cumulative ecosystem change, with the Bay of Quinte as a case study: An essay. Journal of Aquatic Ecosystem Health; Vol. 4, No. 1, pp. 1-24. [Great Lakes Laboratory for Fisheries and Aquatic Science, Burlington, Ontario, Canada]

"Rising concern for the future of humans and the earth's ecosystems provides the backdrop for an essay on approaches to assessing and managing ecosystem health. A review and critique of two rival metaphors of human health, illness and wellness, provide the starting point for evaluation of parallel approaches to the assessment and

management of ecosystems. The limitations of the metaphors are noted for humans and ecosystems. The 'impact assessment' and 'ecosystem approach' concepts of ecosystem assessment and management are contrasted. As a case history, the nature and pace of change in the Bay of Quinte ecosystem are reviewed... The review includes the long-term scientific study of the Bay's response to point-source phosphorous control (Project Quinte) and the recent efforts to develop and implement a coordinated clean-up program (Remedial Action Plan). From the lessons of the Quinte experience, a framework is derived, combining the illness and wellness approaches to health. The framework deals with five topics: uncertainty and the precautionary principle; an ecosystem health scale; indicators of ecosystem health; maximum allowable change; and; regulation and planning.... The framework is briefly discussed and placed in a broader context linking humans and ecosystem, illness and wellness." [from Abstract]

Munawar, M.; Munawar, I.F.; Mayfield, C.I. and McCarthy, L.H. 1989. Probing ecosystem health: A multi-disciplinary and multi-trophic assay strategy. Hydrobiologia; Vol. 188-189, pp. 93-116. [Great Lakes Laboratory for Fisheries and Aquatic Sciences, Canada Center for Inland Waters, Fisheries and Oceans Canada, Ottawa, Ontario, Canada]

"The ecosystem health of stressed environments in the Great Lakes has been evaluated simultaneously by means of a battery of structural and functional tests based on current technology and involving various trophic levels. These tests attempt to assess ecosystem health at the organism level and simultaneously focus on water-borne and sediment-bound toxicities. The use of structural indicators has been successfully demonstrated. Similarly, functional tests were selectively chosen across various trophic levels and included size-fractionated primary productivity (filtered versus unfiltered assays), and Colpidium, Daphnia, Hyalella, and Pontoporeia assays. Some of the emerging techniques such as in situ plankton cages (I.P.C.), microcomputer-based chlorophyll fluorescence (Video Analysis System), and other assays are discussed. The multi-trophic and multi-disciplinary battery of tests followed in our laboratory adopts a field-to-laboratory approach. The availability of diverse bioassays have placed toxicologists and environmentalists in a position where they are now better equipped to probe the complexities of ecosystem health and its management" [Abstract]

Munawar, M.; Munawar, I.F.; Ross, P. and Dermott, R. 1992. Exploring aquatic ecosystem health: A multi-trophic and an ecosystemic approach. I. Rationale and application. Journal of Aquatic Ecosystem Health; Vol. 1, No. 4, pp. 237-252. [Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Canada Center for Inland Waters, Burlington, Ontario, Canada]

"The field of aquatic ecosystem health is a new and developing discipline. The restoration and recovery of habitats is extremely complex and requires a clear understanding of a desirable and maximum/minimum set of conditions which is acceptable, achievable, and cost-effective for implementation. Since this field of research is still in

its infancy, the technology for an integrative and innovative assessment will require a combination of physical, chemical, and biological methods and researchers will have to adopt and use some of the routine chemical, limnological, physiological, ecological, and toxicological procedures. A multi-disciplinary, multi-trophic and an ecosystemic approach has been initiated and applied in the North American Great Lakes during the past several years. This strategy, consisting of structural and functional indicators and endpoints, was implemented in the Great Lakes 'Areas of Concern' adopting a field to laboratory approach for a holistic and integrated evaluation of the ecosystem. Some examples from our Great Lakes experience are presented. The ecosystem health technology should look beyond the traditional approach and must develop innovative, sensitive, automated, and cost-effective procedures including computer-assisted techniques to deal with the problems of stress, healing, recovery, and remediation." [Abstract]

Mweu, N.C. 1995. Environmental impact assessment for sustainable development of coastal and marine resources. In: Coastal Systems and Sustainable Development in Africa. Proceedings of a UNESCO Regional Seminar on Human Impacts on Coastal Ecosystems, their Response and Management Problems, ROSTA, Nairobi, 5-9 April 1993. UNESCO Reports in Marine Science, No. 66. United Nations Educational, Scientific and Cultural Organization, Paris, France. [Kenya Marine and Fisheries Research Institute, Mombasa, Kenya]

"Sustainable development arises from the premise that environment and development are interdependent. Environmental impact assessment studies the effects of a proposed action on both the natural and human environment. The ability to predict changes resulting from specific development proposals can be applied only when there is adequate knowledge on the proposal and the functioning of the aquatic ecosystem features. Therefore, no universal guidelines for assessing ecological impacts, would be applicable to all situations. In this paper a systematic approach for assessing such ecological impacts with particular reference to some existing and proposed developments on the Kenyan coastal zone is presented." [Abstract]

National Research Council of Canada, Associate Committee on Scientific Criteria for Environmental Quality. 1985. The role of biochemical indicators in the assessment of aquatic ecosystem health: their development and validation. NRCC 24371, National Research Council of Canada, Subcommittee on Pesticides and Industrial Organic Chemicals, Ottawa, Canada.

"The pollution of the aquatic environment by industrial organic chemicals of man's activities has long been recognized. Approaches used to define the impacts of contaminants on aquatic ecosystems have classically involved laboratory experiments and, to a lesser extent, field observations on populations. To date, however, there are no available methods that are widely accepted and reliable for determining the degree

of impact of chemical contaminants on aquatic organisms, and the extent of these impacts thus remains essentially undefined.

This document presents an argument for monitoring the biochemical responses of individual organisms to toxic chemicals as a more suitable method of assessing ecosystem health than traditional biological monitoring of populations. The systematic development of biochemical diagnostic tests and their application to environmental management are advocated in order to define a more efficient and realistic strategy for assessing and managing the effects of toxic chemicals in aquatic ecosystems. An analysis of 15 biochemical indicators of ecosystem health in terms of present state of development and future prospects for ecosystem health assessment led to the conclusion that most of the tests, despite showing promise, are still in an elementary stage of development. Specific areas where further research is warranted and could be productive are therefore recommended." [Abstract]

Rapport, D.J. 1995. Ecosystem services and management options as blanket indicators of ecosystem health. Journal of Aquatic Ecosystem Health; Vol. 4, pp. 97-105. [University of Guelph, Guelph, Ontario, Canada]

"A pragmatic and integrative approach to evaluation of the environment combines ecosystem sciences, health sciences, and social sciences. Each has a crucial role to play: the ecosystem sciences provide information on the complex dynamics of ecosystems as they are influenced by stress and disturbance; the health sciences provide a methodology for systematic diagnosis of pathology, taxonomy of ills, and models for preventive as well as rehabilitative modes; the social sciences bring to the fore the importance of human values which are part and parcel of any health evaluation. The complexity of stress-response systems precludes anything approximating a complete understanding of mechanisms underpinning ecosystems transformations. However, the loss of ecosystem services and management options appears to be a general phenomenon that permits an overall evaluation of ecosystem health in both aquatic and terrestrial systems. Such blanket indicators take into account both the impairment of ecosystem function and societal values. This is illustrated by the history of ecosystem transformation in the Laurentian Lower Great Lakes and in the overharvested forest ecosystems of Eastern Canada. In both cases, cultural stress resulted in losses in highly valued ecosystem services and management options. These losses have been partially compensated for by new technologies that have permitted commercial use of the remaining lower quality resources. This process itself, however, may be pathological, reinforcing a degradation sequence rather than serving to restore ecosystem health." [Abstract]

Rapport, D.J. 1992. Evaluating ecosystem health. Journal of Aquatic Ecosystem Health; Vol. 1, pp. 15-24. [Department of Biology, University of Ottawa, Ottawa, Ontario, Canada]

"In the past decade, metaphors drawn from human health are finding increasing application in environmental assessment at ecosystem levels. If ecosystem medicine is to come of age it must cope with three fundamental dilemmas. The first stems from the recognition that there are no strictly objective criteria for judging health. Assessments of health, as in humans, inevitably are based on some combination of established norms and desirable attributes. The second stems from the irregular pulse of nature which either precludes the early recognition of substantive changes or gives rise to false alarms. The third is posed by the quest for indicators that have the attributes of being holistic, early warning, and diagnostic. Indicators that excel in one of these aspects, often fail in another.

Advances in ecosystem medicine are likely to come from closer collaboration with medical colleagues in both clinical and epidemiological areas. In particular the time appears ripe for a more systematic effort to characterize ecosystem maladies, to validate treatments and to develop more sophisticated diagnostic protocols. These aspects are illustrated with comparisons drawn from studies of environmental transformation in the Laurentian Great Lakes, the Baltic Sea and Canadian terrestrial ecosystems." [Abstract]

Reynoldson, T.B. 1993. The development of ecosystem objectives for the Laurentian Great Lakes. Journal of Aquatic Ecosystem Health; Vol. 2, pp. 81-85. [National Water Research Institute, Environment Canada, Burlington, Ontario, Canada]

"Historically management of human use of ecosystems has been based around engineering and chemical approaches and through the construction of treatment facilities, effluent controls and setting chemical concentrations, both at end of pipe and in the aquatic environment. However, the general continued degradation of many ecosystems shows these approaches alone are insufficient. In the Laurentian Great Lakes the Great Lakes Water Quality Agreement was first signed in 1972 and ratified in 1978 and in 1987 tacitly acknowledged the problems with a chemical only approach by requiring the development of ecosystem objectives in the 1978 agreement. Furthermore, the agreement specifically identified numerical ecosystem objectives in the 1987 agreement. The evolution of ecosystem objectives in the Great Lakes has expanded from the strictly numerical objectives such as production of lake trout and abundance of the amphipod *Pontoporeia hoyi*. More recent developments in ecosystem objectives have been the inclusion of indicators for wildlife, habitat, human health and stewardship." [Abstract]

Schaeffer, D.J. 1990. A toxicological perspective on ecosystem characteristics to track sustainable development. Ecosystem health. 7. In: P. Chapman, F. Bishay, E. Power, K. Hall, L. Harding, D. McLeay, M. Nassichuk, and W. Knapp (editors). Proceedings of the Seventeenth Annual Aquatic Toxicity Workshop, November 5-7, 1990, Vancouver, British Columbia, Canada. [University of Illinois, Urbana, Illinois, United States]

Schindler, D.W. 1987. Detecting Ecosystem Responses to Anthropogenic Stress. Canadian Journal of Fisheries and Aquatic Sciences; Vol. 44, pp. 6-25. [Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada]

"Recent ecological work on aquatic populations, communities, and ecosystems is reviewed for advances which show promise as early indicators of anthropogenic stress in aquatic ecosystems. Work at the Experimental Lakes Area (ELA) in northwestern Ontario indicates that among the earliest of responses to stress are changes in species composition of small, rapidly-reproducing species with wide dispersal powers such as phytoplankton, and the disappearance of sensitive organisms from aquatic communities... The importance of long-term monitoring in distinguishing natural from anthropogenic stress is discussed..." [from Abstract]

Schneiders, A.; Verhaert, E.; Blust, G.D.; Wils, C.; Bervoets, L. and Verheyen, R.F. 1993. Towards an ecological assessment of watercourses. Journal of Aquatic Ecosystem Health; Vol. 2, pp. 29-38. [Department of Biology, University of Antwerp, Wilrijk, Belgium]

"Due to a fast decline in the ecological quality of watercourses combined with the threat of human functions, policy makers started to legislate water quality objectives for watercourses and to set up water purification programs. The description of universal quality objectives is too limited as a frame of reference and a policy only based on water quality cannot guarantee the goals of river restoration as a whole. In most countries the need for a more integrated approach of water management is growing. Water quantity must be managed together with water quality, surface water with groundwater, and the water economy with town and country planning.

To restore and maintain the natural diversity of watercourses, together with the natural species richness, policy makers need a frame of reference based on the natural functioning of the ecosystem. The highest level of reference is called the 'ecological naturalness'. Based on the present and the potential ecological value and on the intensity of human uses, policy makers together with a group of scientists should decide on the ecological quality objectives of watercourses. The lowest quality level that must be reached in all watercourses can be described as the 'ecological basic quality'. Together with a frame of reference, there is a need for a refined ecological evaluation method for ecological quality as a whole, and especially to evaluate 'potential ecological values' in an objective way." [Abstract]

Sherman, K. 1994. Sustainability, biomass yields, and health of coastal ecosystems: An ecological perspective. Marine Ecological Progress Series; Vol. 112, No. 3, pp. 277-301. [NOAA/NMFS, Northeast Fisheries Science Center, Narragansett Laboratory, Narragansett, Rhode Island, United States]

"The sustainability, health and biomass yields of marine resources can be enhanced by the implementation of a more holistic and ecologically based strategy for

assessing, monitoring, and managing coastal ecosystems than has been generally practised during most of this century. A major milestone was reached in advancing toward a more ecologically based management practice when the majority of coastal nations of the world endorsed the declaration made at the United Nations Conference on Environment and Development (UNCED) in 1992, to prevent, reduce, and control degradation of the marine environment, so as to maintain and improve its life-support and productive capacities; develop and increase the potential of marine living resources to meet human nutritional needs, as well as social, economic, and development goals; and promote the integrated management and sustainable development of coastal areas and the marine environment. The scientific framework in support of the UNCED objectives is now emerging from a series of regional efforts aimed at cross-sectoral integration of research, monitoring, and assessments conducted to mitigate stresses on coastal ecosystems from toxic effluents, habitat degradation, nutrient loadings, harmful algal blooms, aerosol contaminants, and losses of living resources from pollution and overexploitation. Discipline-oriented ecological studies can contribute more toward achievement of resource sustainability when they are conducted within a framework of science at the level of organization that is multidisciplinary and focused on populations, habitats, and ecosystems at large spatial scales. Primary, secondary, and tertiary driving forces of variability in biomass yields are examined for several large marine ecosystems, along with observations on changing states of 'health' of the systems. Marine resource problems underscored by UNCED are being addressed. Post-UNCED large marine ecosystem-scale programs for advancement toward resource sustainability, ecosystem health, and economically viable biomass yields are now being implemented. The programs are being supported by international agencies as part of an effort to couple recent advances in ecological monitoring, management, and stress mitigation strategies from the more developed countries, with the lesser developed coastal countries around the margins of the ocean basins." [Abstract]

Sherman, K.; Alexander, L.M. and Gold, B.D. (editors). 1993. Large Marine Ecosystems: Stress, Mitigation, and Sustainability. American Association for the Advancement of Science, Washington, DC, United States.

Part One of this book contains articles on the area of 'Sustainability of Large Marine Ecosystems'. Part Two is 'Regional Case Studies - Stress and Mitigation of Large Marine Ecosystems'. The third section covers 'Sustainability and Management of Large Marine Ecosystems', while the final section is devoted to 'Technology Applications to the Monitoring Process in Large Marine Ecosystems'.

Smith, S.J.; Hunt, J.J. and Rivard, D. (editors). 1993. Risk evaluation and biological reference point for fisheries management. Canadian special publication of fisheries and aquatic sciences, 120. National Research Council of Canada, Ottawa, Ontario, Canada.

Contents: 1) Reference points for fisheries management: the western Canadian experience; 2) Reference points for fisheries management: the eastern Canadian

experience; 3) Reference points for fisheries management: the ICES experience; 4) Spawning stock biomass per recruit in fisheries management: foundation and current use; 5) The development of a management procedure for the South African anchovy resource; 6) How much spawning per recruit is enough?; 7) The behaviour of F low, F medium and F high in response to variation in parameters used for their estimation; 8) The Barents Sea capelin stock collapse: a lesson to learn; 9) Assessing the impact of sampling error on model-based management advice: comparison of equilibrium yield per recruit variance estimators (abstract); 10) Variance estimates for fisheries assessment: their importance and how best to evaluate them; 11) Evaluating the accuracy of projected catch estimates from sequential population analysis and trawl survey abundance estimates; 12) Bootstrap estimates of ADAPT parameters, their projection in risk analysis and their retrospective patterns; 13) Analytical estimates of reliability for the projected yield from commercial fisheries; 14) Risk evaluation of the 10% harvest rate procedure for capelin in NAFO Division 3L; 15) Using jackknife and Monte Carlo simulation techniques to evaluate forecast models for Atlantic salmon; 16) Monte Carlo evaluation of risks for biological reference points used in New Zealand fishery assessments; 17) A comparison of event tree risk analysis to Ricker spawner-recruit simulation: an example with Atlantic menhaden; 18) Choosing a management strategy for stock rebuilding when control is uncertain; 19) Risks and uncertainties in the management of a single-cohort squid fishery: the Falkland Islands *Illex* fishery as an example; 20) Risks of over- and under-fishing new resources; 21) Estimation of density-dependent natural mortality in British Columbia herring stocks through SSPA and its impact on sustainable harvesting strategies; 21) The comparative performance of production-model and *ad hoc* tuned VPA based feedback-control management procedures for the stock of Cape hake off the west coast of South Africa; 22) Groundfish exploitation rates based on life history parameters (abstract); 23) A proposal for a threshold stock size and maximum fishing mortality rate; 24) Biological reference points for Canadian Atlantic gadoid stocks; 25) Stochastic locally-optimal harvesting; 26) ITQ based fisheries management; 27) Bioeconomic methods for determining TACs; 28) Management strategies: fixed or variable catch quotas; 29) Bioeconomic impacts of TAC adjustment strategies: a model applied to northern cod; 30) Experimental management programs for two rockfish stocks off British Columbia, Canada; 31) A brief overview of the experimental approach to reducing uncertainty in fisheries management - an extended abstract; 32) Fisheries management organizations: a study of uncertainty. [Contents]

Sustainable Fisheries Network (sponsor). 1989. Proceedings of a workshop on environmentally sustainable economic development for fisheries managers: convened at Winnipeg, May 16th and 17th, 1989. Rawson Academy of Aquatic Science, Ottawa, Ontario, Canada.

Contents: 1. Chairman's welcome and introductory remarks; 2. Overview of the concept of sustainable development; 3. Timetable update; 4. Group discussion of the concept and it implications for resource management; 5. Regional status reports on sustainable development plans and initiatives; 5.1. Atlantic region, 5.2. Ontario, 5.3.

Manitoba, 5.4. Saskatchewan, 5.5. Alberta, 5.6. British Columbia, 5.7. The Arctic; 6. The key issues; 7. The concepts and structure of the sustainable fisheries network; 8. First step initiatives; Appendix A. List of participants; Appendix B. A background perspective on sustainable development (Barry Sadler); Appendix C. The sustainable fisheries network (Dr. Peter Larkin). [Contents]

Sutcliffe, D.W. (editor). 1993. Water Quality and Stress Indicators in Marine and Freshwater Ecosystems: Linking Levels of Organization (Individuals, Populations, Communities). Freshwater Biological Association, Ambleside, United Kingdom.

"In order to strengthen cooperation and collaboration between aquatic scientists, in 1992, the Freshwater Biological Association, Marine Biological Association and Scottish Association for Marine Science, agreed that Joint Associations' Conferences would be held triennially. The first of these took place at Napier University, Edinburgh, in September 1993...

[Techniques were reviewed] for assessing water quality and environmental stress, and to carefully examine their relevance and determine the relationship between one method and another... Particular emphasis was given to the importance of linking the various approaches and methodologies which are used at the different levels of biological organization: the level of the individual, the level of the population, and the level of the community." [from Preface]

ten Brink, B.J.E.; Hosper, S.H. and Colijn, F. 1991. A quantitative method for description and assessment of ecosystems: the AMOEBA approach. Marine Pollution Bulletin; Vol. 23, pp. 265-270. [Ministry of Transport and Public Works, Tidal Waters Division, The Hague, The Netherlands]

"The absence of quantitative and verifiable ecological objectives for Dutch waters impedes the management of those waters. Which activities are admissible and which are not? This article describes the AMOEBA-approach, a conceptual model for the development of quantitative and verifiable ecological objectives. 'AMOEBA' is the Dutch acronym for 'a general method of ecosystem description and assessment'. This model is based on the concept of sustainable development." [Abstract]

Thomas, J.D. 1993. Biological monitoring and tropical biodiversity in marine environments: a critique with recommendations, and comments on the use of amphipods as bioindicators. Journal of Natural History; Vol. 27, pp. 795-806. [Smithsonian Institute, Washington, DC, United States]

"Preoccupations with regulatory and legal liability issues in marine environmental monitoring have led to programmes based on reductionist models that use non-biological parameters which are indirect measures of biotic condition. The ability to assess the effectiveness of current monitoring programmes to protect the marine

environment at regional and national scales does not currently exist. Current monitoring programmes rarely serve the function for which they were intended: an accurate and sensitive source of information from which conditions and trends can be defined and recognized, and management decisions made. In addition, the natural variability of systems is problematic and must be documented in order to distinguish natural from anthropogenic changes in environmental conditions. Owing to their ecological importance, numerical abundance, and sensitivity to a known variety of toxicants and pollutants, amphipod crustaceans have long been known as sensitive environmental indicators. However, application and use of amphipods in such programmes is limited to the few regions where ongoing comprehensive taxonomic and natural history investigations have been undertaken. Potential for amphipods as bioindicators exists in a wide variety of environments, especially in the tropics, but their incorporation into such programmes is dependent upon completion of taxonomic surveys and inventories." [Abstract]

Wever, G.H. 1995. Applying a TQM framework to the public policy process: Part I. The framework. Total Quality Environmental Management; Vol. 4, No. 3, pp. 63-73. [Counc. Great Lakes Ind., Eastman Kodak Co., Rochester, New York, United States]

3. Sustainability Indicators for General and Non-Aquatic Systems

3.1 General and Theoretical Systems

Ayres, R.U. 1996. Statistical measures of unsustainability. Ecological Economics; Vol. 16, pp. 239-255. [Center for the Management of Environmental Resources, INSEAD, Fontainebleau, France]

"Statistical measures are needed to reveal at a glance how far (or near) various countries are to meeting the conditions of long-run sustainability, and how conditions are changing on a year-to-year basis (i.e., whether sustainability is being approached or not). The scheme proposed in this paper presents numerical comparisons of energy and materials use in the real world vis a vis an ideal case where all of the identifiable criteria for sustainability are satisfied. Apart from population stabilization, five general but quantifiable criteria for sustainability are suggested, including (1) stabilization of greenhouse gas concentrations in the atmosphere, (2) stabilization of acidity (pH) in rainfall, (3) reduction of dissipative uses, and wastes, of heavy metals to natural mobilization rates, or lower, (4) elimination of agriculture based on pumping 'fossil' water from non-renewable aquifers and (5) elimination of loss of arable land because of salination or erosion. Other criteria, such as preservation of biodiversity and socioeconomic equity between countries and generations might be added to the list. They introduce more difficult measurement problems, however, which are not considered further in the paper. Having fixed the list of criteria, the next step is to identify measures that either go to zero or unity, as the system approaches more and more closely to sustainability, at least in the limited sense defined above. Various types of measures of sustainability/unsustainability can be developed, viz. (i) measures of relative *dependence* of the economy on non-renewable sources of energy and materials, (ii) measures of the *productivity* of energy and materials consumed by the economic system and (iii) measures of *dissipative loss*, especially of toxic and hazardous substances. Specific examples of each type are discussed." [Abstract]

Azar, C.; Holmberg, J. and Lindgren, K. 1996. Socio-ecological indicators for sustainability. Ecological Economics; Vol. 18, pp. 89-112. [Institute of Physical Resource Theory, Chalmers University of Technology]

"A systematic framework of indicators for sustainability is presented. In our approach there is an emphasis on societal activities that affect nature and on the internal societal resource use, as opposed to environmental quality indicators. In this way the indicators may give a warning signal to an unsustainable use of resources early in the chain from causes in societal activities to environmental effects. The aim is that these *socio-ecological indicators* shall serve as a tool in planning and decision-making processes at various administrative levels in society. The formulation of the indicators is made with respect to four principles of sustainability, which lead to four comple-

mentary sets of indicators. The first deals with the societal use of lithospheric material. The second deals with emissions of compounds produced in society. The third set of indicators concerns societal manipulation of nature and the long-term productivity of ecosystems. Finally the fourth set deals with the efficiency of the internal societal resource use, which includes indicators for a just distribution of resources." [Abstract]

Braat, L. 1991. The predictive meaning of sustainability indicators. In: O. Kuik and H. Verbruggen (editors). In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"In this paper, sustainability indicators are defined as indicators which provide information, directly or indirectly, about the future sustainability of specified levels of social objectives such as material welfare, environmental quality and natural systems amenity. I distinguish two types of sustainability indicators. Firstly, the predictive indicator. This type of indicator provides direct information about the future state and development of relevant socioeconomic and environmental variables. This information constitutes the basis for anticipatory planning and management. The predictive power is based on mathematical models of the man-environment system. The second type is the retrospective indicator. This type includes the traditional policy evaluation and historical trend indicators. They provide information about the effectiveness of existing policies or about autonomous developments, respectively. From these indicators decision-makers may learn and improve policy effectiveness. In this way, retrospective indicators may provide indirect information about future sustainability. They are usually quantified by a combination of measured data and reference values (e.g., historical situations, economic targets, health standards)." [from Introduction]

Clugston, R.M. and Rogers, T.J. 1995. Sustainable Livelihoods in North America. Development: Journal of the Society for International Development; Vol. 3, pp. 60-63. [Center for Respect of Life and Environment, Washington, DC, United States]

"The North American Regional Consultation, focused on the analysis of case studies of communities in Mexico, the Caribbean, Canada, and the United States. Through this process, the participants identified the basic characteristics, indicators, and principles of sustainable livelihoods, and suggested some avenues through which sustainable livelihoods might be promoted and supported in the North American region." [from article]

Hambly, H. 1995. Grassroots Indicators for Sustainable Development. IDRC Reports; Vol. 23, No. 1, pp. 24-26. [Environment and Natural Resources Division, IDRC Regional Office for Eastern and Southern Africa, Nairobi, Kenya]

"All over the world examples... can be found of local people using 'grassroots indicators'; measures or signals of environmental quality and change formulated by

individuals, households and communities, and derived from their local systems of observation, practice and indigenous knowledge. Since the 'environment' is defined here in its widest sense to cross economic, social, cultural, and ecological boundaries, grassroots indicators may be better gauges of well-being than traditional development indicators that are confined to sectors such as health, education or the economy." [from article]

IUCN International Assessment Team. 1995. Assessing Progress Toward Sustainability: A New Approach. The IUCN/IDRC Project on Monitoring and Assessing Progress Toward Sustainability: Approach, Methods, Tools, Progress. In: T.C. Trzyna (editor). A Sustainable World: Defining and Measuring Sustainability Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

"The purpose of this project was to develop and test a practical method of assessing progress toward sustainability. The aim was for the method to be useful and usable in a range of contexts at local, regional, and national levels. To achieve this purpose, IUCN formed an international team and linked it to national teams working on local strategies for sustainability in Colombia, India, and Zimbabwe." [from article]

Kuik, O. and Verbruggen, H. (editors). 1991. In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Papers presented: 1) Indicators of sustainable development: an overview; 2) Towards sustainable development indicators; 3) Note on the correction of national income for environmental losses; 4) GNP and sustainable income measures: some problems and a way out; 5) Natural Resource Accounting: State of the art and perspectives for the assessment of trends in sustainable development; 6) The predictive meaning of sustainability indicators; 7) The AMOEBA approach as a useful tool for establishing sustainable development? 8) Towards sustainability: indicators of environmental quality; 9) Contours of an integrated environmental index for application in land-use zoning. [Contents]

Moffat, I. 1994. On Measuring Sustainable Development Indicators. International Journal of Sustainable Development and World Ecology; Vol. 1, No. 2, pp. 97-110. [University of Stirling, Scotland, United Kingdom]

Stewart, R. 1993. Indicating the Possible. Planning Week; Vol. 3, No. 6, pp. 12-13.

"The scope of this document includes a discussion of current thinking [on indicators of sustainable development]. It proposes that indicators are tools for tracking progress towards sustainable development, measuring its success or otherwise, and

identifying the selection of alternative choices to facilitate a more substantial form of development." [from article]

3.2 Agricultural and Non-Aquatic Resource Systems

Anonymous. 1983. Selected Indicators of Agricultural Development in Asia Pacific Region. RAPA monograph, no. 2. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

Atkinson, G. and Hamilton, K. 1996. Accounting for Progress: Indicators for Sustainable Development. Environment; Vol. 38, No. 7, pp. 16-20 and 40-44.

"This article examines some recent attempts at green accounting and the issues they raise, beginning with simple environmental indicators and then looking at efforts to 'green' the national accounts themselves. It draws two main conclusions: First, efforts to measure sustainable development would be enhanced by expressing indicators of environmental change in monetary terms. Second, linking physical information about the environment to the economic data in the national accounts would be highly useful for policymakers." [from Article]

Baldares C., Dr. M.J.; Gutierrez E., Dr. E.E.; Alvarado H., Dr. A.; and Brenes Q., Lic. L.G. 1993. Desarrollo de un Sistema de Informacion sobre Indicadores de Sostenibilidad Para los Sectores Agricola y de Recursos Naturales de los Paises de America Latina y el Caribe. Development of an Information System of Indicators of Sustainability for the Agricultural and Natural Resource Sectors of Latin American and Caribbean Countries. Instituto de Investigaciones en Ciencias Economicas, Universidad de Costa Rica, San Jose, Costa Rica.

This report proposes a set of indicators of sustainability at the national level, applicable to countries of Latin America and the Caribbean. It then develops an information system for use in calculating suitable indicator values. Finally, the approach is applied to a case study, Costa Rica. Quantitative indicators are determined for: forest resource management, soil management, water resource management, biodiversity conservation, population pressure, income distribution, land ownership, external debt, terms of trade, poverty and deterioration in the quality of life.

Canadian Council of Forest Ministers. 1995. Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators. Natural Resources Canada, Canadian Forest Services, Ottawa, Ontario, Canada.

[This set of] "criteria and indicators are intended to provide a common understanding of what is meant by sustainable forest management in the Canadian context. Collectively, they provide a framework for describing the state of the forests and forest

management, and for periodically demonstrating achievements in implementing sustainable forest management. They identify those elements of the forest ecosystem, as well as our social and economic system, that must be sustained or enhanced." [from Introduction]

Carpenter, R.A. 1995. Limitations in Measuring Ecosystem Sustainability. In: T.C. Trzyna (editor). A Sustainable World: Defining and Measuring Sustainable Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

"Biophysical measurements by which to judge the sustainability of management practices in production and conservation ecosystems are inadequate except in cases of gross and obvious degradation. This unsatisfactory state of the science is due to both a lack of understanding of ecosystems and to the practical difficulties of ecological research. The expectations of participants from other disciplines in the implementation of 'sustainable development' are that the environmental sciences can effectively monitor and predict the outcome of alternative strategies. Since this is generally not so, the limitations of biophysical measurements should be forthrightly communicated so that uncertainties are recognized and the opportunities for improvement can be pursued in a timely manner." [from article]

Cocks, K.D. and Walker, B.H. 1994. Contribution of 'sustainability' criteria to social perceptions of land use options. Land Degradation Rehabilitation; Vol. 5, No. 2, pp. 143-151. [CSIRO Division of Wildlife Ecology, Canberra, Australia]

Copus, A.K. and Crabtree, J.R. 1996. Indicators of Socio-Economic Sustainability: An Application to Remote Rural Scotland. Journal of Rural Studies; Vol. 12, No. 1, pp. 41-54. [Scottish Agricultural College, Aberdeen, United Kingdom]

"Although commonly used and relatively clearly defined in an environmental context, the concept of sustainability tends to be rather nebulous and confusing in the context of rural socio-economic development. In this paper it is defined in terms of three dimensions, structure, performance and dependence. These dimensions are assessed across three groups of socio-economic attributes, those concerned with demographic development, those relating to economic activity, and those associated with community and culture. The resulting sustainability matrix is a potentially valuable tool for assessing the socio-economic status of rural areas in developed countries. This is demonstrated by its application to remote areas in Scotland. In countries such as the U.K., which have a relatively long history of regional assistance, the true demographic and economic constraints of remote rural areas are to a large degree obscured by substantial transfers from more prosperous regions. This dependence is identified as the most important dimension of rural socio-economic sustainability in the Scottish context." [Abstract]

Corson, W.H. 1994. Changing Course: An Outline of Strategies for a Sustainable Future. Futures; Vol. 26, No. 2, pp. 206-223. [Global Tomorrow Coalition, Washington, DC, United States]

"Current trends in population growth, resource use, and environmental degradation, may not be sustainable for more than a few decades. This article summarizes these trends, proposes a broad definition of sustainability that includes ecological, environmental, economic, social, ethical, cultural, and political dimensions, and lists changes needed to make human activity more sustainable. Also considered are barriers to change, general strategies for change, specific agents and instruments of change, and inherent conflicts between social goals and ecological sustainability. More than a hundred indicators are identified for assessing progress toward ecological and societal sustainability at the global, national, and local levels. Examples are given of initiatives representing progress toward a sustainable future." [Abstract]

Craik, J. 1995. Are There Cultural Limits to Tourism? Journal of Sustainable Tourism; Vol. 3, No. 2, pp. 87-98. [Institute for Cultural Policy Studies, Griffith University, Brisbane, Queensland, Australia]

"This article poses the question: are there cultural limits to tourism? It argues that tourism is a culture industry in the sense that it markets cultural products to tourists as cultural experiences. The three elements of tourism as culture are: the cultural foundations of tourism products, the sophistication of tourists' perceptions and experiences of tourist cultures, and the cultural consequences of tourism development on resident communities. Yet these aspects are usually treated in a tokenistic way in favor of economic and environmental considerations, ignoring the cultural consequences of major changes to destination communities as a result of tourist development. This article proposes that the changes and consequences of tourism on the culture of destination communities and on the culture of tourists should be central to debates about sustainable tourism development. This article proposes a number of conditions or indicators to identify the matrix of impacts of tourism from which acceptable and unacceptable limits can be determined. The use of these indicators should be central to planning, management and monitoring practices to achieve sustainable tourism." [Abstract]

DeAlmeida, O.T. and Uhl, C. 1995. Developing a Quantitative Framework for Sustainable Resource-Use Planning in the Brazilian Amazon. World Development; Vol. 23, No. 10, pp. 1745-1764. [Instituto do Homem e Meio Ambiente da Amazonia (IMAZON), Para, Brazil]

"Extensive style logging, ranching, and slash-and-burn agriculture are the principle activities associated with the haphazard settlement of the Eastern Amazon. We

analyze these settlement activities using economic, social, and ecological criteria and then compare them to more intensive approaches to farming, ranching, and forestry. Throughout we consider the costs and benefits of different land-use options, both from the perspective of individual property holders and the common good. We conclude by considering the economic and legislative tools available to local governments wishing to promote sound resource uses in the Brazilian Amazon." [Summary]

Deelstra, T. 1995. The European Sustainability Index Project. In: T.C. Trzyna (editor). A Sustainable World: Defining and Measuring Sustainable Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

The Sustainability Index Project involves 12 European cities. "Its aim was to develop a system of indicators which can be measured in cities throughout Europe. The intention of the Project was 1) to provide cities with a method to make a Local Sustainability Index, 2) to make an inventory or assess the 'state of the environment' in the participating cities, and 3) to compare the cities and report the progress made toward local sustainability." [from Introduction]

de Haes, H.U.; Nip, M. and Klijn, F. 1991. Towards Sustainability: Indicators of Environmental Quality. In: O. Kuik and H. Verbruggen (editors). In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"The quality of societies is often assessed by means of economic standards, although these cover only one aspect of well-being. For determining environmental quality no generally accepted methods are available yet, although there are standards for some aspects of the environment, such as for concentrations of toxic substances. In this contribution, emphasis is on environmental quality, which is a normative concept, of course. A method of assessing environmental quality will be presented, based on research being carried out by the Center of Environmental Science (CML) and the National Institute of Public Health and Environmental Protection (RIVM) in the context of 'region-oriented integration' (Latour et al., 1990; Klijn et al., 1990a; Klijn et al., 1990b)." [from Introduction]

Gameda, S. and Dumanski, J. 1995. Framework for evaluation of sustainable land management: A case study of two rain-fed cereal-livestock farming systems in the Black Chernozemic soil zone of southern Alberta, Canada. Canadian Journal of Soil Science; Vol. 75, No. 4, pp. 429-437. [Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Ottawa, Canada]

"The Framework for Evaluation of Sustainable Land Management (FESLM) was used to assess the sustainability of two land-use systems in the Canadian Prairies.

The FESLM provided a means of identifying the factors impacting on sustainability, the processes by which these factors operate and interact, and the indicators and thresholds by which they could be measured to attain an assessment end point. On the basis of the framework, it was possible to expand sustainability assessment beyond traditional factors of productivity and economic viability to include ones pertaining to production risk, protection of the natural resource base, and social acceptability. In conducting the FESLM-based analysis, the decision-making characteristics of the producer were identified as important components of sustainability. Preliminary indications are that substantially greater amounts of farm-specific and regional data are required to make a conclusive FESLM-based sustainability assessment. Nevertheless, application of the framework suggests that, for the farming systems and the type of producer under consideration, the conservation-based land-use is more sustainable than the conventional land-use system." [Abstract]

Gregerson, H.M. and Lundgren, A.L. 1989. Linking Monitoring and Assessment to Sustainable Development. Working Paper 2. Forestry for Sustainable Development Program, University of Minnesota, St. Paul, Minnesota, United States. [Department of Forest Resources, College of Natural Resources, University of Minnesota, St. Paul, Minnesota, United States]

"To gain the information needed to make more informed choices, monitoring and assessment (M&A) systems are needed, to assess changes both in biophysical and in institutional variables associated with development. To insure that M&A programs provide useful information, they need to be linked closely to the perceived information needs of the people and institutions that determine the course of development. This paper provides an overview of the issues involved in linking M&A to planning and action for sustainable development." [from Introduction]

Hammond, A.; Adriaanse, A.; Rodenburg, E.; Bryant, D. and Woodward, R. 1995. Environmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development. World Resources Institute Report. World Resources Institute, Washington, DC, United States.

"This report attempts to lay a basis for environmental indicators in the context of sustainable development. It briefly surveys past efforts to develop such indicators and reports evidence that they can influence policy decisions. However, it also suggests that indicators based on conventional environmental data won't capture many environmental issues key to sustainable development and identifies the need for additional environmental indicators and for more highly aggregated measures. It suggests new approaches for formulating these indicators and illustrates how such approaches might be carried out. Nonetheless, this report is a work in progress: it also contains ideas and indicator concepts that are preliminary, in the hope that they will stimulate discussion and further work." [from Introduction]

Izac, A-M.N. and Swift, M.J. 1994. On agricultural sustainability and its measurement in small-scale farming in sub-Saharan Africa. Ecological Economics; Vol. 11, pp. 105-125. [International Center for Research in Agroforestry, Nairobi, Kenya]

"We argue in this paper that there is a need to bring the current debate on sustainability down to a more pragmatic level, to 'operationalise' sustainability. Given the diversity of agricultural systems throughout the world, the best that is possible may be to develop proximate definitions that do generate testable theories, as we try to do in this paper by developing a pragmatic and measurable definition of the concept which is relevant to small-scale farming in sub-Saharan Africa...

We try to avoid ecological and economic dogma as far as possible in our discussion of sustainability, attempting to argue instead from what we actually observe in the systems we study. Whilst a great deal of ecological and economic theory may seem at first look to be applicable to the analysis of the sustainability of small-scale agricultural systems, we find that closer analysis reveals the inapplicability of much of what has been subsumed under the titles of agroecology or natural resource economics. Concepts such as stress and disturbance, stability and diversity, community structure, economic optimality, maximum social welfare, do not, on inspection, provide particularly strong predictive power, particularly when applied to the dynamics of resource-poor, small-scale, community-structured, and to a non-negligible extent, non-market-driven agricultural systems." [from Abstract]

Leslie, A.J. 1994. Sustainable management of tropical moist forest for wood. In: Readings in sustainable forestry management. FAO Forestry Paper, 122. Food and Agricultural Organization of the United Nations, Rome, Italy. [School of Agriculture and Forestry, University of Melbourne, Parkville, Australia]

"This paper discusses the feasibility of sustainable management of tropical moist forests for wood production. Emphasis has shifted from considering sustained wood yield as being necessarily the same thing as overall sustainability. The concern is now with sustaining the forest and all of its values rather than just its wood-producing capacity. Although it is difficult to combine conservation with a potentially destructive use such as timber harvesting, it is not impossible. This paper reviews the complexities of sustainable forest management and its components, and reviews experience in Malaysia and in West Africa. From this the determinants for success are identified and the prospects for sustainable forest management in tropical moist forests are discussed. The development and introduction of low-impact management techniques, particularly for harvesting, are stressed." [Abstract]

Manning, T.; Clifford, G.; Dougherty, D. and Ernst, M. 1995. What Tourism Managers Need to Know: A Practical Guide to the Development and Use of Indicators of Sustainable Tourism. Prepared for the World Tourism Organization, Madrid, Spain

by Consulting and Audit Canada, Ottawa, Canada. [Consulting and Audit Canada, Ottawa, Ontario, Canada]

"This guide has two objectives: 1) to facilitate the development of practical indicators for the sustainable management of tourist destinations. This development process will normally occur under the direction of national or regional tourism authorities; and 2) to guide managers and administrators in the use of indicators in decisions regarding tourism and the environment." [from Overview]

Montreal Process. 1995. Sustaining the World's Forests: The Santiago Agreement. Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests. Journal of Forestry; Vol. 93, No. 4, pp. 18-21.

"The Santiago Declaration and its accompanying criteria and indicators were accepted at a meeting of Montreal Process countries in Santiago, Chile, on February 3, 1995. The Montreal Process is an ad hoc process involving nations interested in achieving international-level agreement on principles of sustainable forest management and criteria and indicators for measuring of such principles." [editor's note]

Section one of this document is an introduction and it is followed in section two by a series of definitions of relevant terms. Sections three and four list the seven criteria and indicators for conservation and management of temperate and boreal forests.

Neher, D. 1992. Ecological Sustainability in Agricultural Systems: Definition and Measurement. Journal of Sustainable Agriculture; Vol. 2, No. 3, pp. 51-62. [North Carolina State University, Raleigh, North Carolina, United States]

"'Sustainable agriculture' has emerged as the most agreed-upon term to synthesize a variety of concepts and perspectives associated with agricultural practices that differ from those of conventional production. Definitions of sustainable agriculture contain three equally important components: environmental quality and ecological soundness, plant and animal productivity, and socioeconomic viability. The Agroecosystem component of the Environmental Monitoring and Assessment Program is developing a systems-level approach to the long-term monitoring of agroecosystem sustainability. Measurements will be made for a suite of indicators at sites selected from a probability sampling frame. Associations between indicator values over time will be used to assess agroecosystem condition and status on a regional and/or national scale. One or more measures of sustainability will be developed by organizing indicators and assessment endpoints into a framework based upon the three components of sustainable agriculture." [Summary]

Nilsson, J. and Bergstrom, S. 1995. Indicators for the assessment of ecological and economic consequences of municipal policies for resource use. Ecological Economics;

Vol. 14, pp. 175-184. [Natural Resources Management Institute, Department of Systems Ecology, Stockholm University, Stockholm, Sweden]

"This article focuses on relevant ideals that should be considered in developing an integrated ecological and economic method to facilitate decision-making and the development of a low waste society at the municipal level. This analysis is with the proviso that additional research must be conducted on the input-side of societies' production systems. The interaction between social institutions and the environment is studied with the aid of a systems approach. The main focus of this article is on the social science framework or, more exactly, the sustainable development records (SDR). Material and energy flows are used as representative indicators of impacts on the environmental systems. Three SDR key indicators are proposed, namely: Effectiveness, Thrift, and Margin. Pilot studies of five sewage water treatment plants are presented to illustrate the practical application of the SDR method. Additionally this article compares the SDR method with other endeavors to develop socio-ecological indicators." [Abstract]

Pickup, G. and Stafford-Smith, D.M. 1993. Problems, prospects and procedures for assessing the sustainability of pastoral land management in arid Australia. Journal of Biogeography; Vol. 20, No. 5, pp. 471-487. [CSIRO Division of Wildlife and Ecology, Alice Springs, Northern Territory, Australia]

"Land degradation problems are widely recognized in arid Australia. Such problems arise partly because of a very unpredictable climate, great spatial diversity, and the lack of a conceptual framework within which to base approaches to sustainable land management. Furthermore, the concept of 'sustainability' itself is poorly defined, for good reasons.

Planning for sustainable land use in Australia's rangelands will require assessment of whether pastoral enterprises are sustainable in particular areas. Because of the complexity of the natural and cultural system, there is no simple way of making this assessment. We present a procedure which aims to solve the assessment question efficiently by starting with the least critical and most easily performed analyses and finishing with the most critical and hardest. We suggest determining whether the enterprise is economically viable at a superficial level, then working through the ecological characteristics at increasing levels of complexity, and finally assessing whether the necessary management strategies are socially feasible.

The procedure highlights what can be done using existing understanding and what issues need further research. Despite the latter, efforts must be made to carry out assessments of this kind so the necessary expertise and databases are in place before political expediency forces less objective assessments." [Abstract]

Pykh, Y.A. and Malkina-Pykh, I.G. 1994. Environmental Indicators and Their Applications (Trends of Activity and Development). Working Paper 94-127. International Institute for Applied Systems Analysis, Laxenburg, Austria. [Center for Interna-

tional Environmental Cooperation (INENCO), Russian Academy of Sciences, St. Petersburg, Russia]

"The present paper includes an overview of the state of environmental indicators (Part I) and application of the response function method to the indicators issue (Part II). The main goal of this paper is to give information on further development of environmental indicator activity. As the application of the environmental indicators is of special interest to IIASA's Projects entitled 'Forests Resources, Environment, and Socioeconomic Development of Siberia' and 'Modeling Land Use and Land Cover Change in Europe and Northern Asia' the paper is mainly focused on the formation of indicators for the land-use and forest studies." [from Forward]

Rees, W.E. 1996. Revisiting Carrying Capacity: Area-Based Indicators of Sustainability. Population and Environment: A Journal of Interdisciplinary Studies; Vol. 17, No. 3, pp. 195-217. [School of Community and Regional Planning, University of British Columbia, British Columbia, Canada]

"Conventional wisdom suggests that because of technology and trade, human carrying capacity is infinitely expandable and therefore virtually irrelevant to demography and development planning. By contrast, this article argues that ecological carrying capacity remains the fundamental basis for demographic accounting. A fundamental question for ecological economics is whether remaining stocks of natural capital are adequate to sustain the anticipated load of the human economy into the next century. Since mainstream (neoclassical) models are blind to ecological structure and function, they cannot even properly address this question. The present article therefore assesses the capital stocks, physical flows, and corresponding ecosystems areas required to support the economy using 'ecological footprint' analysis. This approach shows that most so-called 'advanced' countries are running massive unaccounted ecological deficits with the rest of the planet. Since not all countries can be net importers of carrying capacity, the material standards of the wealthy cannot be extended sustainably to even the present world population using prevailing technology. In this light, sustainability may well depend on such measures as greater emphasis on equity in international relationships, significant adjustments to prevailing terms of trade, increasing regional self-reliance, and policies to stimulate a massive increase in the material and energy efficiency of economic activity." [Abstract]

Rees, W.E. and Wackernagel, M. 1994. Ecological Footprints and Appropriated Carrying Capacity: Measuring the Natural Capital Requirements of the Human Economy. In: A.M. Jansson, M. Hammer, C. Folke and R. Costanza (editors). Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press, Washington, DC, United States.

"This chapter advances a novel approach to estimating the natural capital requirements of the economy based on considerations of human carrying capacity. We

begin by contrasting conventional economic rationality with economic principles. Many economists reject the notion that carrying capacity imposes serious constraints on material growth on grounds that substitution and imports can overcome local resource constraints. However, monetary analyses are themselves incapable of producing useful estimates of the physical stocks and processes required to sustain defined human population. We therefore develop an empirical approach to this measurement problem based on reinterpretation of carrying capacity that can account for technological advances and trade." [from Abstract]

Riley, L.F. 1982. Criteria and Indicators of Sustainable Forest Management in Canada. Water, Air and Soil Pollution; Vol. 82, No. 1-2, pp. 67-70. [Canadian Forest Service, Hull, Quebec, Canada]

"Sustainable forest management is an international as well as a Canadian domestic concern. Sustainability is characterised by a framework of criteria and associated indicators which identify its principal attributes and the parameters which can be measured to assess the extent to which sustainability is being achieved. Canada is developing a set of criteria and indicators of sustainable forest management for domestic purposes, and is participating in a number of similar international initiatives which will establish international norms for sustainability. Harmonization of these various initiatives will ensure international acceptance and understanding amongst global regions of similar and dissimilar forest zones. Implementation, a follow-up goal, will ensure that the principal objectives of sustainable forest management, as espoused by the National Forest Strategy for Canada, are achieved." [Abstract]

Sands, G. and Podmore, T.H. 1993. Development of an environmental sustainability index for irrigated agricultural systems. In: K.C. Klein and D.J. Williams (editors). Seeking an Integrated Approach To Watershed Management in the South Platte Basin. Colorado Water Resources Research Institute, Colorado State University, Fort Collins, Colorado, United States. [Department of Agricultural and Chemical Engineering, Colorado State University, Fort Collins, Colorado, U.S.]

Schaenman, P.S. 1976. Using an Impact Measurement System to Evaluate Land Development. The Urban Institute, Washington, DC, United States.

[This report] "summarizes the results of a study aimed at improving procedures that cities, counties, and higher levels of government may use for evaluating land use changes - whether proposed private developments or changes stemming from public action such as comprehensive planning and zoning. The procedures also may be used for evaluating the impacts of previous development. It should be noted at the outset that many types of impacts are more appropriately considered in the context of general growth patterns, as discussed in work on comprehensive plans, rather than on the basis of one-by-one assessments of single developments.

The study considers practical ways to assess a broad range of impacts: on the local economy, the environment, public and private services, and on aesthetic, cultural, and social conditions of the community. Where possible, the impacts are described in terms of *end results to people* rather than in intermediate or technical terms. The procedures are intended to help governments comply with impact assessments required by federal and state laws, as well as for their own purposes.

The study accomplishes three major tasks:

* It identifies the state of the art of practical measurement procedures available to local (and other) governments for estimating various types of impacts.
* It sets forth an illustrative system of measures for assessing impacts of proposed development, identifying data collection and analysis procedures for each measure.
* It reflects initial testing of the measurement system undertaken with the cooperation of three communities: Phoenix, Arizona; Indianapolis/Marion County, Indiana; and Montgomery County, Maryland. The focus was on testing the system as a whole rather than on individual estimation methodologies. This experience provides insights on how to implement a measurement system, and certain advantages and disadvantages of the approach." [from Summary]

Senanayake, R. 1991. Sustainable Agriculture: Definitions and Parameters for Measurement. Journal of Sustainable Agriculture; Vol. 1, No. 4, pp. 7-28. [Centre for Farm Planning and Land Management, Faculty of Agriculture and Forestry, University of Melbourne, Parkville, Victoria, Australia]

"Sustainable agriculture is seen as an important goal throughout the world. The notion of sustainability in the agricultural sector has been described mainly through three schools of thought: economic, social, and ecological. Most general works have indicated the need to integrate the needs of all these schools into a common descriptor. A composite index that recognises the value of economic and ecological schools of thought is suggested. In this model sustainability is seen as a dynamic process where measure can be applied only relative to earlier states." [Abstract]

Sheehy, G. 1989. The use of indicators to show the state and recent trends in sustainable development: a forestry pilot study. Technical Report, No. 11. Strategies and Scientific Methods, SOE Reporting Branch, Canadian Wildlife Service, Conservation & Protection, Environment Canada, Ottawa, Canada.

"A recent study by the author, titled The Use of Indicators to Show the State and Recent Trends in Sustainable Development in Canada, presented a framework for measuring changes and trends in socio-economic activities as indicators of a move toward sustainable development. This report presents results of a forestry pilot study which was conducted to implement the concept set forth in the earlier study." [from Introduction]

Smyth, A.J. and Dumanski, J. 1993. FESLM: An International Framework For Evaluating Sustainable Land Management. World Soil Resources Reports, 73. Land and Water Development Division, Food and Agricultural Organization of the United Nations, Rome, Italy.

"This report proposes a strategic framework approach for evaluating sustainable land management. This approach is advocated because the concept of what constitutes sustainability cannot be rigid, it needs to be capable of change from area to area and over time. As solutions become more precise they will have to be increasingly location and time specific. A strategic framework approach offers the possibility of providing preliminary estimates, of acceptable reliability, without waiting for all of the final data. The approach is intended to be generic and universal and it assists in organizing the concepts and principles to be used in deriving a solution. It is intended as an aid to guide decisions towards sustainable management, to increase the probability of success and/or identify potential failures. It should certainly assist in interpreting the results of the very many research initiatives that are now in progress in the search for sustainability." [from Introduction]

Syers, J.K.; Hamblin, A. and Pushparajah, E. 1995. Indicators and Thresholds for the Evaluation of Sustainble Land Management. Canadian Journal of Soil Science; Vol. 75, No. 4, pp. 423-428. [International Board for Soil Research and Management, Bangkok, Thailand]

"Within the context of major land uses such as agriculture, the indicators of sustainability must be framed within the social and economic conditions of the society in question. Whereas an indicator is used to measure changes in key attributes, usually over time, a threshold provides a baseline against which sustainability can be assessed. A direct measure of sustainability using indicators is difficult, and indirect measures or surrogates may be easier to establish. There is some information on threshold values for indicators, particularly for indicators such as soil acidity and nutrient status, and for those relating to root physiology. Because some threshold values are soil specific, it seems likely that range of values will be required for a particular indicator. There have been few case studies involving indicators and thresholds for sustainable land management. Examples of soil and land suitability for the production of *Hevea brasiliensis* (rubber) in Malaysia and for the management of sloping lands for annual crops in the Philippines are discussed. Biophysical indicators and thresholds for sustainable rubber production appear to be reasonably well-understood, particularly those relating to climate and soil physical factors. For sloping lands in the Philippines, yield data and benefit:cost ratios give a clear picture of trends and sustainability." [Abstract]

ten Brink, B. 1991. The AMOEBA approach as a useful tool for establishing sustainable development? In: O. Kuik and H. Verbruggen (editors). In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"The concept of sustainable development is a political rather than a scientific concept. It is a balance between the environment and human uses. If policy-makers want to make rational choices concerning sustainable development, they have to define this concept and formulate verifiable ecological objectives, and moreover they will need to possess adequate economic and ecological information. The need for verifiable ecological objectives and adequate ecological information gave rise to the AMOEBA approach. This chapter reflects on the concept of sustainable development and gives a short description of the AMOEBA approach. Finally, the possibilities of the AMOEBA approach for finding quantitative indicators for sustainable development are evaluated." [Summary]

van Pelt, M.J.F.; Kuyvenhoven, A. and Nijkamp, P. 1995. Environmental sustainability: issues of definition and measurement. International Journal of Environment and Pollution; Vol. 5, No. 2-3, pp. 204-223. [Ministry of Economic Affairs, The Hague, The Netherlands]

"Operationalization of the concept of sustainable development requires the formulation of sustainability indicators and of techniques to assess scores on such indicators. A flexible approach is proposed, which incorporates several normative issues (including intergenerational welfare and substitution of manufactured capital for natural capital) and leads to a choice of location-specific sustainability constraints. Key parameters include classes of environmental resources, threshold levels, spatial level and time path. Assessing the score on this sustainability indicator involves the measurement of the difference between actual and normative levels of resource use. Depending on the measurement scale at which information becomes available, multi-criteria analysis may be useful to arrive at overall sustainability scores." [Abstract]

Western Environmental and Social Trends, Inc. (W.E.S.T.). 1991. Measuring Sustainable Development: Energy Production and Use in Canada. Working Paper Number 12. National Round Table on the Environment and the Economy (NRTEE), Ottawa, Ontario, Canada.

This report focuses on the measurement of sustainable development in energy production and use nationally, through (a) an outlining of criteria for sustainability, (b) development of a set of macro indicators, together with discussion of support for these indicators, and (c) presentation of micro indicators and finally more alternative ones. Future directions in this area are discussed in the conclusion.

Winograd, M. 1995. Environmental Indicators for Latin America and the Caribbean: Tools for Sustainability. In: T.C. Trzyna (editor). A Sustainable World: Defining and Measuring Sustainable Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

"The goal of the present work is to prepare a set of indicators that might be used in the evaluation and design of environmental policies. Besides defining descriptive indicators that may allow a quantitative evaluation of a given situation, normative indicators are used to compare reference values and to show in what direction we must proceed. For this we used a rational methodology that will permit select retrospective and prospective environmental indicators in relation to the main issues related to the environment and development." [from article]

World Tourism Association. 1993. Indicators for the Sustainable Management of Tourism. International Institute for Sustainable Development Report of the International Working Group on Indicators of Sustainable Tourism to the Environment Committee, World Tourism Organization, Madrid, Spain.

Young, M.D. and Ryan, S.A. 1995. Using Environmental Indicators to Promote Environmentally, Ecologically, and Socially-Sustainable Resource Use: A Policy-Orientated Methodology. EPAT/MUCIA Manual, No. 3. EPAT/MUCIA Research and Training, Madison, Wisconsin, United States. [CSIRO Division of Wildlife and Ecology, Canberra, Australia]

"This manual demonstrates how to rapidly identify indicators of progress toward the sustainable use of natural resources. The methodology has a strong policy orientation. Although focused on natural resource issues, the methods can be equally useful in addressing health, economic, education or many other policy areas." [from Introduction]

3.3 International and National Indicators

Adger, W.N. and Grohs, F. 1994. Aggregate estimate of environmental degradation for Zimbabwe: Does sustainable national income ensure sustainability? Ecological Economics; Vol. 11, No. 2, pp. 93-104. [Center for Social and Economic Research on the Global Environment (CSERGE), University of East Anglia, Norfolk, United Kingdom]

"Standard measures of economic growth do not adequately reflect changes in aggregate welfare over time. Sustainable national income is therefore defined as Net National Product with adjustments for the degradation of renewable and non-renewable capital. Productivity loss rather than replacement cost is the most theoretically correct way to value resource depletion. Modified net product is estimated for the agriculture and forestry sectors of Zimbabwe by valuing the loss of forest stock and soil erosion. The results show that traditional measures overstate the value of the agricultural sector's product by approximately 10% in 1989. It is argued that indicators of sustainable national income do not ensure sustainable development; as with all macroeconomic indicators, they do not account for distributional and equity issues which are at the crux

of sustainable development, nor do they point to mechanisms that would ensure sustainable resource management. Rising sustainable income over time is therefore a necessary but not sufficient condition for the achievement of sustainable development." [Abstract]

Ahmad, Y.J.; El Serafy, S. and Lutz, E. (editors). 1989. Environmental Accounting for Sustainable Development. The World Bank, Washington, DC, United States.

"This volume contains selected papers from a series of workshops jointly sponsored by the World Bank and the United Nations Environmental Programme (UNEP)... The chapters in this volume reflect different aspects and approaches to environmental accounting. They are concerned mostly with financial and economic considerations and the prospects of modifying the U.N. System of National Accounts (SNA) to reflect issues of environmental and natural resource concern." [from Preface]

Anonymous. 1994. Indicators for Sustainable Development: Strategies for Use of Indicators in National Reports to the Commission on Sustainable Development and in the EC Structural Funds Process. World Wide Fund for Nature, Surrey, United Kingdom and New Economics Foundation, London, United Kingdom.

Anonymous. 1989. Redefining wealth and progress: new ways to measure economic, social, and environmental change: the Caracas report on alternative development indicators. Report of the International Meeting on More Effective Development Indicators, Caracas, Venezuela, July 31- August 3, 1989. Knowledge Systems, Indianapolis, Indiana, United States & The Bootstrap Press, New York, N.Y., U.S.

"The [Caracas] meeting noted the limitations to the advisability of the Gross National Product (GNP) continuing to be the main reference for measuring development and pointed out formulas for correcting or improving it in order to obtain a more integral and effective means of measuring the socioeconomic condition of peoples. This in turn was complemented by the proposal for parameters to measure the quality of life in such aspects as poverty, the biological condition of infancy, health, education, nutrition, employment and income, pollution and the destruction of natural resources. Also discussed was how this measurement could be harmonized at the international level, as was once the case with the GNP, so that countries might speak a 'common language' and make a better job of channeling the collective effort in favor of development." [from Forward]

Arntzen, J. and Gilbert, A. 1991. Natural Resource Accounting: State of the art and perspectives for the assessment of trends in sustainable development. In: O. Kuik and H. Verbruggen (editors). In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"This paper discusses progress in [the] field of Natural Resources Accounting (NRA), assesses the method's possibilities and restrictions and, more specifically, its potential as a monitoring tool of sustainable development. The findings are based on a literature review and on research into NRA conducted at the Institute for Environmental Studies (e.g., Gilbert and Hafkamp, 1986; Perrings *et al*, 1988; Perrings *et al*, 1989; Gilbert *et al*, 1990)." [from Introduction]

Bartelmus, P. 1994. Green accounting for a national strategy of sustainable development - the case of Papua New Guinea. Ambio; Vol. 23, No. 8, pp. 509-514. [United Nations Statistical Division, New York, New York, United States]

"Interdependencies between socioeconomic activities and environmental processes call for integrated approaches in planning and policy formulation to achieve long-term sustainable growth and development. Integrated ('green') environmental and economic accounting provides indicators and leads to policy variables that aim at such integration. The results of a case study of integrated accounting in Papua New Guinea are used to illustrate possible uses and limitations of such accounting in national policies and strategies of sustainable development. A broad policy framework incorporating green accounting concepts and recommendations of a post-UNCED seminar in Papua New Guinea is outlined." [Abstract]

Daly, H.E. 1991. Elements of Environmental Macroeconomics. In: R. Costanza (editor). Ecological Economics: The Science and Management of Sustainability. Columbia University Press, New York, New York, United States. [Environment Department, The World Bank, Washington, DC, United States]

"Environmental economics is traditionally treated as a subdivision of microeconomics. The focus is on getting prices right for optimal allocation. It is argued that in addition there is a neglected macroeconomic question, that of optimal scale, that is independent of optimal allocation, and must be served by an independent policy instrument. The issue of optimal scale, reasons for its neglect, definition, and policy implication are discussed." [Abstract]

Duthie, D. 1993. How to grow a green economy. New Scientist; Vol. 137, No. 1858, pp. 39-43. [Oxford Brookes University]

This article looks at the best way to measure a country's financial health. Historically, GDP and GNP have been used, however the recognized weakness of these are their inability to account for environmental degradation. The UN Development Programme's human development index (HDI) is a more complete indicator taking into account various welfare statistics. After discussing these indicators, they are integrated into a discussion on sustainable development.

Hannon, B. 1992. Measures of Economic and Ecological Health. In: R. Costanza, B.G. Norton, and B.D. Haskell (editors). Ecosystem Health: New Goals for Environmental Management. Island Press, Washington, DC, United States.

This article discusses the derivation of an indicator of ecosystem health, the gross ecosystem product (GEP), that represents the ecological equivalent of the GNP, a weighted number based on all activities in the ecosystem. The importance of utilizing such a measure in practice is noted through contrast with the GNP, as the traditional economic indicator.

Henderson, H. 1990. Beyond Economics: New Indicators for Culturally Specific, Sustainable Development. Development: Journal of the Society for International Development; Vol. 3-4, pp. 60-68. [Saint Augustine, Florida, United States]

"Hazel Henderson examines the potential for the UN fourth development decade to produce more realistic indicators of development. She suggests that the already important work by socially concerned economists, statisticians and sociologists of the past years should be used to ensure greater government accountability and to improve the overall quality of life of its citizens." [Abstract]

Henderson, H. 1990. From Economism to Systems Theory and New Indicators of Development. Technological Forecasting and Social Change; Vol. 37, No. 3, pp. 213-233. [Saint Augustine, Florida, United States]

"The 1990's, designated by the United Nations as the Fourth Development Decade, are ushering in a new global debate re-defining the very concept of development beyond traditional Eurocentric models of industrialism. This article overviews these issues and their post-Cold-War context, and attempts to reframe today's North-South and East-West debates over debt, aid, ecological destruction, changing technologies, markets and values, within alternative paradigms of 'progress' beyond conventional economic measurements. New indicators of wealth and sustainable human development are offered, within an interdependent world trade model." [Abstract]

Marshall, I.B.; Hirvonen, H. and Wiken, E. 1993. National and regional scale measures of Canada's ecosystem health. In: S. Woodley, J. Kay and G. Francis (editors). Ecological Integrity and the Management of Ecosystems. Sponsored by Heritage Resources Center, University of Waterloo, and Canadian Parks Service, Ottawa. St. Lucie Press, Delray Beach, Florida, United States. [Environment Canada, Ottawa, Ontario, Canada]

"This chapter outlines initiatives of State of the Environment Reporting to identify national and regional scale indicators of ecosystem health. These indicators are being developed within an ecological framework that allows the consideration of issues ranging in scale from local to continental or global." [from article]

Opschoor, H. 1991. GNP and sustainable income measures: some problems and a way out. In: O. Kuik and H. Verbruggen (editors). In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"It is well recognized that measures of gross national product (hereafter GNP) do not reflect all features of societal developments that are relevant from a welfare theoretical point of view. Corrections of GNP or substitute income-based measures (such as 'Sustainable Income') have been proposed for decades. In this brief Chapter, some of the work towards such corrections and substitutions is reviewed. It is argued that rather than correcting GNP or seeking one-dimensional substitutes, policy-making might - in the short term - be served best by the provision of a (small but relevant and consistent) set of indicators for environmental quality and/or (un)sustainability. Meanwhile economic research should lead to better methods for valuing costs of elimination and/or environmental damage." [Introduction]

Pearce, D.W. and Atkinson, G.D. 1993. Capital theory and the measurement of sustainable development: An indicator of 'weak' sustainability. Ecological Economics; Vol. 8, No. 2, pp. 103-108. [Center for Social and Economic Research on the Global Environment (CSERGE), University College London, London, United Kingdom]

"The measurement of sustainable development is not without considerable difficulties, yet this should not detract from the positive advances that can be made in this direction. In this paper we present one form that a 'weak' sustainability indicator can take. Derived from a simple but intuitive savings rule, it incorporates the idea that the level of overall capital stock should be non-decreasing. Although subject to qualification at this stage, some interesting results emerge from the application of the rule to 18 countries." [Abstract]

Ruitenbeek, H.J. 1991. Indicators of Ecologically Sustainable Development: Towards New Fundamentals. Canadian Environmental Advisory Council, Environment Canada, Ottawa, Ontario, Canada.

"This paper commences with a broad look at the principles of the 'new fundamentals', focusing on some of their key elements and how they are relevant in a policy context. It then discusses how each of the main technical issues contributes to the conclusion that these principles are important and independent of the technical disagreement which can and does arise in specific indicator design. Next, the discussion examines these fundamentals in the context of some specific example indicators. From

this, the paper concludes with a description of the next steps which might be taken in applying these fundamentals." [from Introduction]

Sheng, F. 1995. National Economic Indicators and Sustainable Development. In: T.C. Trzyna (editor). A Sustainable World: Defining and Measuring Sustainable Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

[This article acknowledges] "that sustainable development has ecological, social, and economic dimensions. Accordingly, sustainable development should be measured along these three dimensions at local, national, and international levels. In this context, the article looks at economic indicators at the national level in relation to sustainable development." [from Introduction]

Tiwari, D.N. 1995. Measurement of Sustainability Indicators and Implications for Macroeconomic Policy Modelling in Developing Countries. Economie Appliquee; Vol. 48, No. 2, pp. 181-214. [Agricultural Department, FAO, Rome, Italy]

"This paper reviews sustainability concepts and measures sustainability indicators in the context of a least developed country Nepal and a developing country Thailand in order to judge the economy's performance with regard to the use of natural resources and the environment. In both the country cases, natural resource scarcity is increasing, environmental quality is deteriorating, and the domestic resource gap is increasing. A conceptual framework is developed for linking corrected sustainable national income for Nepal. Finally, implications for macroeconomic policy modelling using sustainability indicators are discussed." [Abstract]

Winter-Nelson, A. 1995. Natural Resources, National Income, and Economic Growth in Africa. World Development; Vol. 23, No. 9, pp. 1507-1519. [University of Illinois, Urbana-Champaign, Illinois, United States]

"Because standard measures of aggregate income such as gross domestic product (GDP) do not account for natural resource depletion, their use as gauges of economic performance tends to exaggerate the benefits of resource extraction. Accounting for natural resource depletion in 18 African countries indicates different patterns of growth than those suggested by GDP figures. Use of the revised measures in analyses of the link between exports and growth suggests that export expansion may generate increases in measured GDP without stimulating increased production. In contrast, real exchange rate allignment is correlated with growth in both conventional GDP and the revised accounts." [Abstract]

4. Background: Non-Aquatic Systems

Bartelmus, P. 1994. Environment, Growth, and Development: The concepts and strategies of sustainability. Routledge, London, United Kingdom. [United Nations Statistical Division, New York, United States]

"Focusing on operational, quantifiable concepts and methods, [this] book systematically links the different policies, strategies and programs of growth and development to advance an integrative policy framework for sustainable development at local, national and international levels in both developing and industrialized countries." [from opening]

Braat, L.C. and Steetskamp, I. 1991. Ecological-Economic Analysis for Regional Sustainable Development. In: R. Costanza (editor). Ecological Economics: The Science and Management of Sustainability. Columbia University Press, New York, N.Y., U.S. [Institute for Environmental Studies, Free University, Amsterdam, Netherlands]

"In this paper, we focus on five aspects of open regional system development: the roles of non-renewable and renewable resources, the importance of trade and exchange flows, the position of environmental and resource policies, and the succession of subsystems in the course of development. We introduce a generic, aggregate economic-ecological model for analysis of regional development processes and trace the dynamics of sustained development in a case study of a region in the Netherlands." [Abstract]

Brown, B.J.; Hanson, M.E.; Liverman, D.M. and Merideth, R.W.Jr. 1987. Global Sustainability: Toward Definition. Environmental Management; Vol. 11, No. 6, pp. 713-719. [Institute for Environmental Studies, University of Wisconsin, Madison, Wisconsin, United States]

"Sustainability is increasingly viewed as a desired goal of development and environmental management. This term has been used in numerous disciplines and in a variety of contexts, ranging from the concept of maximum sustainable yield in forestry and fisheries management to the vision of a sustainable society with a steady-state economy. The meaning of the term is strongly dependent on the context in which it is applied and on whether its use is based on a social, economic, or ecological perspective. Sustainability may be defined broadly or narrowly, but a useful definition must specify explicitly the context as well as the temporal and spatial scales being considered. Although societies differ in their conceptualisations of sustainability, indefinite human survival on a global scale requires certain basic support systems, which can be maintained only with a healthy environment and a stable human population. A clearer understanding of global sustainability and the development of appropriate indicators of

the status of basic support systems would provide a useful framework for policy making." [Abstract]

Carley, M. 1981. Social Measurement and Social Indicators: Issues of Policy and Theory. Contemporary Social Research Series, 1. George Allen & Unwin Ltd., London, United Kingdom.

"Chapter 1 looks at the relatively simple concept of a social indicator and explores the spectrum of activity constituting the social indicator movement. The historical antecedents of social indicators are identified as are the important early landmarks of the movement. The basic problem areas in social measurement are contrasted with the compelling need for reliable social information. Chapter 2 goes on to examine the definition problems which have plagued social indicator research since its inception, and then draws out the most useful components of the best definitions, organized according to policy use and statistical sophistication. Various dimensions of social indicators are examined, including subjective indicators and quality-of-life studies. Chapter 3 suggests that systems of social indicators can be best understood by the way they are structured, and goes on to examine a number of such systems being developed, and in use, in different countries and by international agencies.

Chapter 4 explores the critical relationship between social indicators and social theories and models, and examines the major difficulties which impede the development of causal and predictive social indicator models. A simple conceptual framework is proposed for orientating and integrating research efforts. Chapter 5 examines social indicators in the policy making process, and argues that for policy-relevant indicators the role of social scientific method must be considered in the light of the basic elements of the policy process: value-conflict, bureaucratic maintenance and analytic rationality. Policy constraints on social indicators are associated with non-use, misuse, quantification, value-judgements, distributional equity and value-weighted schemes. Means for overcoming political dilemmas and constraints are discussed.

Chapter 6 looks at the field of national social reporting, with special emphasis on the audience, the problems and the prospects for social reports in the UK and the USA. Chapter 7 explores in detail three different applications of social indicators to urban analysis: for classifying neighborhoods within cities, for comparisons among cities and countries and for assessing performance in the delivery of urban services. Examples are drawn from both North American and UK experiences. Chapter 8 sums up the critical issues and arguments of the book and looks to the future of social indicators." [from Preface]

Center for International Development and Environment. 1992. Toward an environmental and natural resources management strategy for ANE (Asia and Near East) countries in the 1990s. Submitted to The Asia and Near East Bureau, U.S. Agency for International Development, by the Center for International Development and Environment, World Resources Institute, Washington, DC, United States.

"The report contains five chapters. Chapter I provides the analytic framework that links natural resources, their extent, quality, and management with economic growth in the region. Chapter II contains a more detailed description and analysis of a number of key resource problems that are restricting economic growth and have a severe impact on opportunities to improve the standard of living and quality of life of citizens in the region. Chapters III and IV contain 20 specific opportunities for working toward sustainable economic growth through protection and enhancement of the natural resource base... Chapter V presents a set of principles and criteria that we recommend using to help establish priorities for action in individual countries and in the region." [from Preface]

Conway, G.R. 1985. Agricultural Ecology and Farming Systems Research. In: Remenyi, J.V. (editor). Agricultural Systems research for Developing Countries: Proceedings of an international workshop held at Hawkesbury Agricultural College, Richmond, New South Wales, Australia, 12-15 May 1985. Australian Centre for International Agricultural Research, Canberra, Australia.

"Agroecosystem Analysis and Development is based on the disciplines of agricultural ecology and human ecology, and in this paper I begin with a presentation of some of the key concepts. This is followed by a summary of the method of analysis, giving examples of its application drawn from several workshops held in recent years in Indonesia and Thailand. I then discuss the challenge of agroecosystem design and development with some comments on implementation."

The procedure for agroecosystem analysis consists of three parts. First, system definition deals with objectives and with a boundaries hierarchy. Second, pattern analysis concerns indicators of performance, key questions or guidelines, and hypotheses. Finally, research design and implementation involves aspects of experiments, surveys, and trials.

Costanza, R. 1991. Assuring Sustainability of Ecological Economic Systems. In: R. Costanza (editor). Ecological Economics: The Science and Management of Sustainability. Columbia University Press, New York, New York, United States. [Center for Environmental and Estuarine Studies, University of Maryland, Solomons, Maryland, United States]

"Assuring sustainability of ecological economic systems depends on our ability to make local and short-term goals and incentives (like local economic growth and private interests) consistent with global and long-term goals (like sustainability and global welfare).

Traditional sustainable cultures have used systems of taboos, religious mores, etc., (arrived at largely through trial and error) to bring long-term goals and constraints into the local, short-term decision making process. Our global environmental crisis is such that we don't have the time or flexibility to use trial and error or to comprehensively instil the appropriate taboos and mores. Institutions and policies that can use our

current, uncertain, scientific understanding of the possible future consequences of current activities to adjust the local, short-term decision-making process quickly and effectively must be developed. This requires:

* Establishing a *hierarchy* of goals for local, national and global ecological economic planning and management. Sustainability should be the primary long-term goal, replacing the current focus on GNP growth. Local economic growth in this hierarchy is a valid goal to the extent that it is consistent with sustainability. Ecological economists can help to develop and popularize this hierarchy of goals, and the underlying world view. The goals can be operationalized by having them accepted as part of the political debate, and implemented in the decision making structure of institutions that affect the global economy and ecology (such as the World Bank).
* Developing better *global ecological economic modeling* capabilities to allow us to see the range of possible outcomes of our current activities. Ecological economists can play a major role in this.
* Adjusting current prices to reflect long-run, global costs, *including uncertainty*. To paraphrase the popular slogan, we should: model globally, adjust local incentives accordingly. In addition to traditional education, regulation and user fee approaches, a flexible assurance bonding system can specifically address uncertainty.
* Developing policies that lead to no further decline in the stock of *natural capital*. These policies will encourage the technological innovation that optimists are counting on, while conserving resources in case the optimists are wrong." [Abstract]

Costanza, R.; Daly, H.E. and Bartholomew, J.A. 1991. Goals, Agenda, and Policy Recommendations for Ecological Economics. In: R. Costanza (editor). Ecological Economics: The Science and Management of Sustainability. Columbia University Press, New York, New York, United States. [Center for Environmental and Estuarine Studies, University of Maryland, Solomons, Maryland, United States]

"This introductory chapter: 1) Summarizes the state and goals of the emerging transdisciplinary field of *ecological economics*, particularly as regards issues of sustainability; 2) provides a working agenda for research, education and policy for the coming decade to ensure sustainability; 3) provides some policy guidelines and recommendations for achieving these goals." [from Abstract]

Costanza, R. and Patten, B.C. 1995. Defining and Predicting Sustainability. Ecological Economics; Vol. 15, pp. 193-196. [Center for Environmental and Estuarine Studies, University of Maryland, Solomons, Maryland, United States]

"This paper attempts to separate the definition of sustainability (which is argued to be quite straightforward) from related issues concerning: (1) which system, subsystem, or characteristics are to be sustained; (2) for how long they are to be sustained; and (3) when we can assess whether the system has actually been sustained. We argue that because we can only assess sustainability after the fact, it is a prediction problem

more than a definition problem. We also propose that in order for evolutionary adaptation to occur, there must be an ordered, hierarchical relationship between the expected (finite) life-spans of systems and their space and time scales." [Abstract]

Daly, H.E. and Cobb, J.B. Jr. 1989. For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future. Beacon Press, Boston, Massachusetts, United States.

"Part One of this book views economics as it is [with]... two major elements: the characteristics of an academic discipline and the deductive model. We illustrate the consequences for economics with respect to selected basic concepts: the market, measures of success, *Homo economicus*, and the land... Part Two presents an alternative approach to the economy. Instead of shaping the study to the requirements of a science, this approach proposes that reflection be ordered to the needs of the real world... The topics treated in Part One are reconsidered from this point of view in the same sequence... Part Three proposes policies that would follow from this different perspective... Part Four discusses how changes in the required direction might come about." [from Introduction]

Dasgupta, P. and Maler, K.-G. 1989. Social Cost Benefit Analysis and Soil Erosion. In: F. Archibugi and P. Nijkamp (editors). Economy and Ecology: Towards Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"In this article it is our purpose to present some of the salient features of social cost-benefit analysis and then to show how to conduct it systematically for environmental projects. Towards this we will first outline the logic of social cost-benefit analysis in a non-technical manner, highlighting the role played in such analyses by considerations of the distribution of income among contemporaneous people, as well as people separated by time. The next sections will apply these ideas to environmental problems. We will first identify certain pervasive forces that are known to trigger environmental degradation. Our illustrations will be based exclusively on land resources, and by environmental degradation we will thus mean loss in land productivity or land fertility. Furthermore, our examples will be motivated by land degradation in Sahelian Africa. Having identified certain key forces that result in land degradation we will then suggest two classes of policies that could be used in confronting these problems. One of them has been much discussed in the literature and is often pursued in practice. This is direct investment aimed at increasing the resource base; that is, expending resources to regenerate, to revive, the productivity of degraded soil. Replanting trees and reseeding the soil are examples of such investment in land reclamation. We will, by way of a case study, discuss such policies." [from Introduction]

de Graaf, H.J.; Musters, C.J.M. and ter Keurs, W.J. 1996. Sustainable development: looking for new strategies. Ecological Economics; Vol. 16, pp. 205-216. [Institute for Evolutionary and Ecological Sciences, University of Leiden, Leiden, The Netherlands]

"Many strategies have been proposed to reach sustainable development. A great many of these strategies aim at one type of problem - preventing environmental deterioration - while ignoring the importance of economic or social goals. In addition, while political decisions are at the heart of the choices to be made, most researchers seem to consider sustainable development as a mere technical problem. In this paper we describe a more complete strategy for sustainable development. We use the outlines of this strategy to find out what knowledge and skills are needed. The strategy is based on the idea that it is necessary to find consensus on the development of a socio-environmental system as a whole, and between all people involved. It leaves us with at least two main areas that need further study: the supply of information and management of consensus building. A formal procedure for consensus building might be developed based on the literature and on experiences with Environmental Impact Assessments. Special attention is paid to the information needed. It can be summarized as information about: (1) delimiting a socio-environmental system; (2) the needs and wants to be satisfied via the system; and (3) the physical, ecological, economic, social and cultural constraints of satisfying those needs and wants." [Abstract]

Dixon, J.A. and Hufschmidt, M.M. (editors). 1986. Economic Valuation Techniques for the Environment: A Case Study Workbook. John Hopkins University Press, Baltimore, United States.

"The seven case studies included in this book illustrate how the various economic techniques discussed in the companion 'Guide' can be used to value environmental and natural systems effects of development projects...

Complementing the case studies are three introductory chapters. In Chapter 1 the role of economics in the valuation of environmental effects of development projects is briefly presented in a real world context. Chapter 2 consists of a hypothetical case study that takes the reader through both financial and economic analyses of a project, pointing out economic fallacies and errors to be avoided. In the final introductory chapter, the topics of economic time horizon and discounting are discussed and some computational aids are presented. These introductory chapters are designed to help the users of the case studies in working through the economic valuation exercises." [from Preface]

Dover, M.J. and Talbot, L.M. 1987. To Feed the Earth: Agro-Ecology for Sustainable Development. World Resources Institute, Washington, DC, U.S.

"This paper defines and describes an ecological approach to agriculture that differs profoundly from the industrial approach that has dominated agriculture research

and development for decades. Both have their place, but - as regarded here - the main issue is how to incorporate the former into agricultural development...

The idea is not to abandon the methods of industrial agriculture that have been so successful in the economic and ecological conditions for which they were designed, but to determine where such methods as mechanization, use of agricultural chemicals, and monoculture are and are not appropriate, and to develop alternative systems better suited to tropical climates and developing economies. This study lays out steps - stretching from basic research to the mechanics of international assistance - that must be taken if ecologically based agriculture is to contribute all it can to feeding the earth." [from Forward]

Dovers, S.R. 1995. A framework for scaling and framing policy problems in sustainability. Ecological Economics; Vol. 12, No. 2, pp. 93-106. [Center for Resource Environmental Studies, Australia National University, Canberra, Australia]

"It is argued that a necessary, but lacking, component of our approach in seeking policy responses to sustainability issues is some repeatable means whereby the relative magnitude and characteristics of these various policy problems faced in a given context can be analysed and described. To this end, a simple and tentative framework is constructed, based on the definition of the key attributes which shape policy problems pertaining to environmental change. These are: spatial scale of cause and effect; magnitude, timing and longevity of possible impacts; reversibility; mensurability; complexity and connectivity; nature of cause(s); relevance to the given polity; tractability (availability and acceptability of means); public concern; and existence of goals. These attributes inform a general taxonomy of micro-, meso- and macro-problems. The attributes and the taxonomy are described with supporting examples. To illustrate possible application of the framework, it is discussed briefly in the contexts of operationalising the 'precautionary principle', and policy instrument choice. It is concluded that the framework can help focus debate and operationalise vague principles, introduce relativity into the notion of sustainability, and make policy choice more efficient." [Abstract]

Folke C. 1991. Socio-Economic Dependence on the Life-Supporting Environment. In: C. Folke and T. Kaberger (editors). Linking the Natural Environment and the Economy: Essays From the Eco-Eco Group. Kluwer Academic Publishers, Dordrecht, The Netherlands. [Department of Systems Ecology, Stockholm University, Stockholm, Sweden]

"This chapter discusses the emerging ecology-economy perspective outlined by many systems ecologists and a growing number of economists. This perspective emphasizes the interrelations between socioeconomic development and the life-supporting ecosystems. The role of the environment in supporting the economy is identified, and related to growth and sustainability issues. The challenge is to enable the agents of the human economy to fit the socioeconomic systems into biogeochemical

cycles, so as to maintain the life-supporting environment and hopefully extend the life of resources in fixed supply. Input management of human production systems and the development of ecotechnology are suggested as important tools for approaching such a goal." [Abstract]

Friend, A.M. and Rapport, D.J. 1991. Evolution of macro-information systems for sustainable development. Ecological Economics; Vol. 3, pp. 59-76. [Institute for Research on Environment and Economy, University of Ottawa, Ottawa, Ontario, Canada]

"The changing perception of the 'environmental problem', as articulated in the Brundtland Report, has shifted the issue of environment information from an almost exclusive focus on pollution towards changes in natural productivity and resource depletion. This has reoriented environmental data needs towards the macro-perspective of national accounting as reflected in natural resource stocks and flows, indicators of the state of environment and sustainable development. The Stockholm Conference (1972) raised the question of the need for a system of environment statistics, complementary to, and integratible with, the body of social and economic statistics. We propose here a conceptual framework which tracks stocks and flows of natural resources, incorporates a critical set of indicators of ecological integrity at the eco-region level, and has the capacity to integrate certain parameters in the System of National Accounts (SNA), with those found in Natural Resource Accounts (NRA), and State of Environment Reporting (SOE Reports). The emphasis is on the applied side of macro-information systems of 'ecological economics' as it has so far evolved from the experience of 'official government statistics'. The final section briefly reviews developments in Canada and suggests some future directions." [Abstract]

Gottfried, R.R.; Brockett, C.D. and Davis, W.C. 1994. Models of sustainable development and forest resource management in Costa Rica. Ecological Economics; Vol. 9, No. 2, pp. 107-120. [Department of Economics, The University of the South, Sewanee, Tennessee, United States]

"The Osa Peninsula and its Golfo Dulce Forest Reserve, which contain the largest remaining forest on Costa Rica's Pacific coast, currently experience great pressures from smallholders clearing for agriculture and gold mining. The paper compares the sustainability of Costa Rica's current model of extensive government intervention on the Osa, combined with natural forest management, to a proposed relatively free-market approach also promoting the same package of technological change and industrial promotion. Concluding that the current approach fails to promote sustainable development, the authors propose an alternative free-market-oriented approach that, while not without its own risk, represents a much more feasible and, therefore, potentially more successful approach to the country's deforestation problems. The authors point out that it might not be possible to provide a sustainable income on the Osa for all the residents of the peninsula and to maintain secondary forest cover at

the same time. Policymakers must be clear about what they want to sustain, who receives the benefits, and who bears the costs of their sustainable development efforts." [Abstract]

Gregerson, H.M.; Lundgren, A.L. and White, T.A. 1994. Improving Project Management for Sustainable Development. EPAT/MUCIA Policy Brief No. 7, The Environmental and Natural Resources Policy and Training Project. EPAT/MUCIA, University of Wisconsin, Madison, Wisconsin, United States. [University of Minnesota, St. Paul, Minnesota, United States]

"Sustainable development is a widely used term that is defined in many ways. While its breadth of interpretation makes it politically appealing, it also makes the concept confusing as a point of reference for any concrete project activity.

Most discussions focus on political or policy level issues and global concerns. However, the needs are just as important, although less dramatic, at the project level. This policy brief focuses on the elements of a policy framework to improve the contributions of projects to sustainable development." [from article]

Hancock, T. 1993. Health, human development and the community ecosystem: three ecological models. Health Promotion International; Vol. 8, No. 1, pp. 41-47. [Kleinburg, Ontario, Canada]

"Health, as both an expression and a component of human development, has to be seen in an ecological manner as 'the pattern that connects' and the radical and subversive nature of an ecological approach needs to be recognized. Three ecological models are presented, that of health; the links between health, environment and economy (or between 'health for all' and sustainable development); and the social, environmental, and economic dimensions of a healthy and sustainable community.

The 'mandala of health', as a model of the human ecosystem, presents the determinants of health as a set of nested influences ranging from the biological and personal to the ecological and planetary, including the social and political.

The health-environment-economy model describes crucial links between health (social well-being) and environmental and economic wellbeing, with a particular focus on two key public health principles - equity and sustainability. The final model applies these concepts at the community level, introducing such issues as viability, convivial-ity, and liveability.

These models could be used to better understand health, to define key criteria for healthier public policies and to define some key action areas for healthy city projects. It is in their application that their value - and their 'subversiveness' - will be tested." [Abstract]

Henderson, H. 1994. Paths to Sustainable Development: The Role of Social Indicators. Futures; Vol. 26, No. 2, pp. 125-137. [Saint Augustine, Florida, United States]

"This article reviews the current debate about new indicators of wealth and progress and how the meaning of development is changing. The goal of sustainable development is to clarify the confusion of *means* (i.e. the current obsession with economic growth) with truly evolutionary human development as the *ends* to be pursued within the ecological tolerances of the planet. The article also reviews the debate about overhauling national accounts as provided for in Agenda 21 and how best to augment such 'scorecards' with additional indicators of overall progress and quality of life. A historical overview of the social indicators movement is combined with a discussion of newer indicators of environmental costs & benefits. This debate is nothing less than a tug-of-war of paradigms, epistemology, and methodology." [Abstract]

Inter-American Institute for Cooperation on Agriculture (IICA). 1991. Toward a Working Agenda for Sustainable Agricultural Development. Program Paper Series 25. Inter-American Institute for Cooperation on Agriculture (IICA), San Jose, Costa Rica.

"Ensuring the sustainability of agricultural production is the most important challenge on the international agenda for the 1990s. The present document outlines, from a Latin American perspective, the different dimensions involved in moving toward sustainable agriculture. Beginning with a brief analysis of the concept of sustainability, the document then examines the magnitude of the problems to be overcome in achieving sustainable agriculture: deforestation, pollution and ecological imbalance caused by the misuse of agrochemicals, the degradation of soils and the loss of genetic diversity." [from Summary]

Interorganizational Committee on Guidelines and Principles for Social Impact Assessment. 1994. Guidelines and Principles for Social Impact Assessment. United States Department of Commerce, NOAA Technical Memorandum NMFS-F/SPO-16.

"In this monograph... we define social impact assessment in terms of efforts to assess or estimate, in advance, the social consequences that are likely to follow from specific policy actions (including programs, and the adoption of new policies) and specific government actions (including buildings, large projects and leasing large tracts of land for resource extraction), particularly in the context of the *U.S. National Environmental Policy Act of 1969* or 'NEPA' (P.L. 91-190, 42 U.S.C. 4371 *et seq.*" [from Introduction]

IUCN International Assessment Team. 1996. Assessing Progress Toward Sustainability: Methods and Field Experiences. An IUCN/IDRC Project. Strategies for Sustainability Programme. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland.

The overview of this work contains discussion on the concept, approach, and methods of assessing progress toward sustainability. Three field experiences, Colombia, Zimbabwe, and India, are then outlined. Appendix 1 details methods of system assessment; Appendix 2, methods of self assessment; and Appendix 3, methods of project assessment. Appendix 4 outlines tools and training material.

IUCN/UNEP/WWF. 1991. Caring for the Earth: A Strategy for Sustainable Living. The World Conservation Union (IUCN), United Nations Environment Programme (UNEP), World Wide Fund for Nature (WWF), Gland, Switzerland.

"Part I... begins with a chapter that defines principles to guide the way toward sustainable societies... The following eight chapters recommend activities that will give substance to the principles.

Part II... describes corresponding actions that are required in relation to the main areas of human activity and some of the major components of the biosphere. These chapters deal with energy; business, industry, and commerce; human settlements; farm and range lands; forest lands; fresh waters; and ocean and coastal areas. Each chapter begins with a brief survey of the issue with which it deals. This is followed by a series of recommended priority actions.

Part III... consists of one chapter which proposes guidelines to help users adapt the strategy to their needs and capabilities and implement it, and sets out how the sponsors propose to follow up the Strategy and involve the community of users in its follow-up. It also contains a listing of all the recommended priority actions and suggested targets." [from user's guide]

Jacob, M. 1994. Toward a Methodological Critique of Sustainable Development. The Journal of Developing Areas; Vol. 28, No. 2, pp. 237-251. [Institute for Theory and Science Research, University of Gothenburg, Gothenburg, Sweden]

[A requirement to realize the objectives of sustainable development] "is that the formulation must be able to meet the metatheoretical criteria that determine the ability of a framework to effectively guide research and ultimately the development of policies to achieve a given set of objectives. These metatheoretical criteria include rigorous and analytical definitions of the objectives and the concepts or constructs used to meet them. Meeting this criterion would also ensure the internal and external consistency of sustainable development by making it easier to integrate the already completed empirical work on sustainable development with extant knowledge on development. This paper employs such metatheoretical criteria to examine the conceptual framework of sustainable development. Using this approach, the paper determines that the inadequacies of sustainable development with respect to these criteria severely restrict its capacity to engender research and policy that can achieve sustainable development. The paper concludes by advancing recommendations for overcoming some of these drawbacks." [from article]

James, D.E.; Nijkamp, P. and Opschoor, J.B. 1989. Ecological Sustainability and Economic Development. In: F. Archibugi and P. Nijkamp (editors). Economy and Ecology: Towards Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"This chapter gives a fuller interpretation of the concept of sustainable development, noting the economic significance of the biosphere in providing part of the economy's capital stock. From an economic viewpoint, key questions that must be answered include:
- what is the optimal size and composition of the economy's environment capital stock?
- how successfully can the tools of economic analysis be applied to environmental management?
- how should the problems of risk and uncertainty in ecological management be handled?
- to what extent should goals other than economic efficiency be taken?"
[from Introduction]

Jansson, AM. and Jansson, B.-O. 1994. Ecosystem Properties as a Basis for Sustainability. In: AM. Jansson, M. Hammer, C. Folke, and R. Costanza (editors). Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press, Washington, DC, United States. [Department of Systems Ecology, Stockholm University, Stockholm, Sweden]

"The somewhat late realization of the finite character of the natural resources has led to a healthy reevaluation of their basic role in the economics of mankind. Because the natural systems form the basis for economic development and sustainability, their short- and long-term dynamics and structure have to be recognized and fully understood. The evolution of ecological economics as an extended 'ecological regime' is both qualitatively and quantitatively dependent on an adequate understanding of the behavior of living systems. The stimulating participation in this evolution has for us repeatedly highlighted basic, but apparently less well-known properties of the ecosystem, which, when neglected, often cause adverse and unexpected results of environmental management practices. This chapter highlights a series of ecologically established concepts and their implications for the choice of investment strategies, such as gross and net production of ecosystems and their maintenance costs; biodiversity and its energetic background; fragmentation, patchiness, and metapopulation concepts; resistance and resilience; stability domains and equilibrium points; self-maintenance and succession; and life-support systems and life-support area." [Abstract]

Kadekodi, G.K. 1992. Paradigms of Sustainable Development. Development: Journal of the Society for International Development; Vol. 3, pp. 72-76. [Institute for Economic Growth, Delhi, India]

[This article] "gives an overview of the analytical debates behind the concept of sustainability by widening the economic notion of development to include philosophical, social, and ecological perspectives. The present method of evaluating development which leaves out environmental and social costs is no longer viable. In order to translate the theory of sustainable development into practice we need to identify and measure the ecological, cultural, economic, social demographic, historical, and regional factors." [Abstract]

Kaufmann, R.K. and Cleveland, C.J. 1995. Measuring sustainability: needed - an interdisciplinary approach to an interdisciplinary concept. Ecological Economics; Vol. 15, pp. 109-112. [Center for Energy and Environmental Studies, Boston University, Boston, Massachusetts, United States]

"We argue that the sustainability of human systems can be understood by integrating concepts and indicators proposed by social and natural scientists. Sustainability is based on the balance between the ever-changing types and quantities of environmental life support used by society, and the long-run ability of natural ecosystems to provide life support. This balance can be evaluated by criteria that combine the strengths of social indicators, which measure the economic and technical factors that determine the use of life support, and natural science indicators, which model the long run ecological effects of using life support." [from Introduction]

Kumar, R.; Manning, E.W. and Murck, B. 1993. The Challenge of Sustainability. Project Learning, Center for a Sustainable Future at the Foundation for International Training, Don Mills, Ontario, Canada. [Foundation for International Training, Don Mills, Ontario, Canada]

"Part 1, 'Understanding and Measuring Environmental Problems,' explores the 'need to know'... The chapters in the first section focus on understanding the evolution of the global problematique; challenging traditional value systems; broadening the perspectives of managers; and acknowledging and comprehending the new responsibilities facing today's managers. Enhancing the quality and accessibility of environmental information, facilitating the communication and sharing of such information, and developing new standards by which to measure our problems and progress are fundamental steps in enriching our understanding of human-planet relationships.

...Part II, 'Working Towards Sustainable Solutions,' surveys some of the comprehensive approaches and strategies available to help managers meet the challenges of sustainability. Effective application of integrated planning and decision-making approaches like Environmental Impact Assessment (EIA) and Geographic Information Systems (GIS) can greatly enhance our understanding of environmental problems and fundamentally transform management perspectives. Strengthening the participative and consultative aspects of the strategic planning process and developing more effective methods of promoting sustainable management are important aspects of this exploration of new approaches and strategies." [from Preface]

Leistritz, F.L. and Murdock, S.H. 1981. The socioeconomic impact of resource development: methods for assessment. Social impact assessment series, no. 6. Westview Press, Inc., Boulder, Colorado, United States. [North Dakota University, North Dakota, United States]

"For both decision makers and professional social scientists... there is a critical need for a single source that can provide information on the conceptual, methodological, and pragmatic considerations related to socioeconomic impact assessment methods. This work is an attempt to address this need. Specifically it attempts to: (l) describe the conceptual and methodological approaches and specific techniques for assessing the major economic, demographic, public service, fiscal, and social impacts of resource development and the patterns of interrelationship among these impact categories; (2) delineate the policy considerations and information needs related to each type of impact; and (3) present the state-of-the-art of impact assessment for projecting each of the types of impacts and their integration." [from Preface]

Miller, F.P. and Wali, M.K. 1995. Soils, land use and sustainable agriculture: A review. Canadian Soil Science; Vol. 75, No. 4, pp. 413-422. [School of Natural Resources, The Ohio State University, Columbus, Ohio, United States]

"Viewing soils in the full context of landscape ecology is imperative. Both land and its component soil resources are finite. The biological capability of the earth's ecosystems is limited, even though agriculture productivity has been manipulated by genetic selection of plants, adjusting nutrient flows, managing water, and controlling pests. However, these interventions also have serious economic and environmental repercussions. Increasing populations require more space, more food, more fuels, and more of other resources. For soil scientists, the challenge is to (a) understand soil processes, (b) characterize and map soil resources, (c) predict soil behaviour under a variety of potential uses in the interest of providing society and its governing institutions with options and trade-offs in land use decisions. Global and regional economic and agricultural productivity will depend solely on our ability to increase productivity by (a) making economic-agricultural development congruent with ecological and social-political realities, (b) proper use and conservation of indigenous genetic resources, and (c) rehabilitating disturbed and degraded ecosystems. In this review, we assess these considerations and suggest needed strategies." [Abstract]

Mitchell, B. 1994. Sustainable development at the village level in Bali, Indonesia. Human Ecology; Vol. 22, No. 2, pp. 189-211. [Department of Geography, University of Waterloo, Waterloo, Ontario, Canada]

"Using a stress-capability framework, the problems and opportunities for sustainable development at the village level in Bali are examined. Balinese culture

incorporates a traditional form of local government which emphasizes cooperation, consensus building, and balance. These aspects provide a strong foundation for sustainable development initiatives. At the same time, many decisions are being taken external to the villages, and even to Bali, which may lead to problems for development initiatives." [Abstract]

Moser, A. 1994. Trends in biotechnology: Sustainable technology development: From high tech to eco tech. Acta Biotechnology; Vol. 14, No. 4, pp. 315-335. [Technical University of Graz, Graz, Austria]

Munasinghe, M. 1993. Environmental economics and biodiversity management in developing countries. Ambio; Vol. 22, No. 2-3, pp. 126-135. [Policy and Research Division, Environment Department, World Bank, Washington, DC, United States]

"Reconciling and operationalizing the three main concepts of sustainable development - the economic, ecological, and sociocultural - poses formidable problems. Environmental economics and valuation can play a key role in helping to incorporate concerns about biodiversity loss into the traditional decision-making framework. A case study from Madagascar examines the impact of a new national park on tropical forests by using both conventional and newer techniques to economically value damage to forests and watersheds, timber and nontimber forest products, other impacts on local inhabitants, impacts on biodiversity, and ecotourism benefits. In the Sri Lanka case study, an integrated energy-environmental analysis was developed, which helps to eliminate projects with unacceptable impacts, and redesign others. Where economic valuation of environmental impacts was not possible, multiple attribute evaluation techniques were used. Improving the incomes and welfare of local communities, especially poor ones, while simultaneously preserving physical and biological systems, offers opportunities for developing countries to pursue all three goals of sustainable development in a complementary manner." [Abstract]

Munasinghe, M. and Shearer, W. (editors). 1995. Defining and Measuring Sustainability: The Biogeophysical Foundations. The International Bank for Reconstruction and Development/ The World Bank, Washington, DC, United States.

Contents: 1) The Meaning of Sustainability: Biogeophysical Aspects. 2) Key Concepts and Terminology of Sustainable Development. 3) Limits to Sustainable Use of Resources: From Local Effects to Global Change. 4) Sustainability: The Cross-Scale Dimension. 5) Cumulative Effects and Sustainable Development. 6) Managing Landscapes for Sustainable Biodiversity. 7) Scale and Sustainability: A Population and Community Perspective. 8) Sustainability and the Changing Atmosphere: Assessing Changes in Chemical and Physical Climate. 9) Sustainability at Landscape and Regional Scales. 10) Indicators of Biophysical Sustainability: Case Study of the Chaco Savannas. 11) The Sustainability of Natural Renewable Resources as Viewed by an

Ecologist and Exemplified by the Fishery of the Mollusc *Concholepas concholepas* in Chile. 12) Sustainable Development and the Chesapeake Bay: A Case Study. 13) Restoration of Arid Lands. 14) Currencies for Measuring Sustainability: Case Studies from Asian Highlands. 15) Large Marine Ecosystems and Fisheries. 16) Sustainable Agriculture in the Tropics: Issues, Indicators, and Measurement. 17) Biophysical Measurement of the Sustainability of Temperate Agriculture. 18) Measuring Sustainability in Tropical Rangelands: A Case Study from Northern Kenya. 19) Indicators of Grassland Sustainability: A First Approximation. 20) Sustainability in Tropical Inland Fisheries: The Manager's Dilemma and a Proposed Solution. 21) Sustainable Development of Fisheries in Southeast Asia. 22) Sustainability of Temperate Zone Fisheries: Biophysical Foundations for Its Definition and Measurement. 23) Sustainability of Managed Temperate Forest Ecosystems. 24) Sustainable Management of Temperate Wildlife: A Conceptual Model. 25) Sustainability of Wildlife and Natural Areas. 26) Tropical Water Resource Management: The Biophysical Basis. 27) Limitations in Measuring Sustainability.

Niu, W.-Y.; Lu, J.J. and Khan, A.A. 1993. Spatial Systems Approach to Sustainable Development: A Conceptual Framework. Environmental Management; Vol. 17, No. 2, pp. 179-186. [Department of Geography, University of Northern Iowa, Cedar Falls, Iowa, United States]

"Even though 'sustainable development' seems to have emerged as the development paradigm of the 1990s, a great deal of vagueness still surrounds the meaning, definition, and theoretical underpinnings of the concept. There is also a general lack of emphasis on the spatial dimension of sustainable development when developing relevant conceptual or environmental accounting frameworks. In clarifying the concept, this article proposes a definition that explicitly incorporates the temporal as well as the spatial dimension of sustainability. It also develops a logically consistent conceptual framework for the analysis and evaluation of sustainable development, following a spatial systems approach. Five interconnected spatial subsystems or subsets of a spatial system are identified and their respective operational dimensions discussed. A proposed composite index called degree of sustainable development (DSD) and its five component indicators are also outlined. The difficulties involved in operationalizing the DSD measure and the conceptual framework are noted, and the various tasks that need to be undertaken in this regard are specified. It is concluded that future research utilizing the proposed conceptual framework should not only foster the development of appropriate methodologies for the comparative evaluation of sustainable development at global, national, and regional scales, but also offer insights to appropriate decision makers at various levels regarding available options and alternative actions for the healthy development of their respective societies." [Abstract]

Norton, B.G. 1991. Ecological Health and Sustainable Resource Management. In: R. Costanza (editor). Ecological Economics: The Science and Management of Sustainabil-

ity. Columbia University Press, New York, New York, United States. [Georgia Institute of Technology, Atlanta, Georgia, United States]

"A contextual approach to environmental management requires a distinction between Resource Management, the management of a resource-producing cell such as a field or fishery, and Environmental Management, which involves concern for the larger systems which environ those cells. Mainstream natural resource economics defines sustainability mainly by reference to undiminished outputs of economically marketable products and emphasizes productivity criteria in judging management regimens. This approach is appropriate in many cases for guiding Resource Management but, taken alone, it provides no guidance regarding the protection of the larger, environmental context of resource-producing activities.

Aldo Leopold, and most environmentalists following him, have applied a contextual approach in which resource-producing cells are understood as subsystems of larger, slower-changing (but still dynamic) ecological systems. According to this approach, Resource Management should be limited when resource-producing activities approach a threshold beyond which they alter larger systems and instigate rapid change in environing systems. Metaphorically, this result is referred to as 'illness' in the ecological community, but the rules and criteria for describing these limits have never been stated precisely in ecological terms. A definition of 'ecosystem health,' based on biologically formulated criteria for judging larger ecological systems, will be proposed and integrated into a hierarchical approach to environmental management." [Abstract]

O' Connor, J.C. 1995. Toward Environmentally Sustainable Development: Measuring Progress. In: T.C. Trzyna (editor). A Sustainable World: Defining and Measuring Sustainable Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

Section 1 of this article discusses synthesizing the available information on environmentally sustainable development and the benefits of doing so.

"Section 2 suggests a possible framework for a new 'report card', which was created by cobbling together existing initiatives... Section 3 considers how the report card approach could help communication between those trying to complete various parts of the whole and those more concerned with broad goals and knowing whether actions are being taken to attain those goals. Section 4 notes practical considerations, including the key question of what can realistically be expected from the first set of ESD indicators." [from article]

Opschoor, H. and Reijnders, L. 1991. Towards sustainable development indicators. In: O. Kuik and H. Verbruggen (editors). In Search of Indicators of Sustainable Development. Kluwer Academic Publishers, Dordrecht, The Netherlands.

"...In this paper a first attempt is made to arrive at a system of indicators of the condition of the environment in terms of its capacity to sustain economic activity. Sustainability indicators reflect the reproducibility of the way a given society utilizes its environment. Hence, they differ from classical environmental indicators: they do not simply reflect environmental conditions or the pressures on the environment, but they indicate to what degree certain pressures or environmental impacts the earth can deal with in a long-term perspective, without being affected in its basic structures and processes. We refer to this capacity of the environment as 'ecological viability'. In a sense, therefore, sustainability indicators are normative indicators: they relate actual, 'objective' developments to a desirable condition or goal." [from Introduction]

Orians, G.H. 1990. Ecological Concepts of Sustainability. Environment; Vol. 32, No. 9, pp. 10-15, 34. [Institute for Environmental Studies, University of Washington, Seattle, Washington, United States]

"In principle, society could ..., choose to value equally every living thing and every environmental process or attribute. In practice, however, an insistence on valuing everything equally results in little value being given to anything. Environmental assessment and management are best served when people explicitly choose a limited number of 'valued ecosystem components' (VECs). People can use these VECs as guides in decisionmaking and tradeoffs when evaluating particular cases of development. A VEC can be a single species of economic (deer) or aesthetic (California condor) value, systems of interacting species (bees with the plants they pollinate), or an entire ecosystem (a wetland or rain forest)." [from article]

Panayotou, T. 1993. Green Markets - The Economics of Sustainable Development. Copublication of the International Center for Economic Growth and the Harvard Institute for International Development.

"*Green Markets* is the third volume in the cooperative publication effort of ICEG and HIID and the seventh in ICEG's series of Sector Studies, which examine developing countries' responses to specific policy problems. Here, Theodore Panayotou presents clear and thoughtful analysis on how economics both explains environmental degradation and suggests solutions. The key is the proper valuation of resources.

Using abundant examples of success and failure, Panayotou makes the case that environmental degradation at the current rate is bad economics - but there is a solution. Government policies, he points out, often unwittingly create and exacerbate environmental degradation, because they generally do nothing to correct its root causes. What governments must do, and what some have done successfully, is to create market conditions for environmental resources. Panayotou shows that simply by pricing irrigation water appropriately, for instance, governments could increase agricultural yields, manage scarce water more efficiently, improve equity among farmers, and gain revenues." [from Preface]

Pearce, D.W.; Barbier, E.B. and Markandya, A. 1990. Sustainable Development: Economics and Environment in the Third World. Edward Elgar Publishing Limited, Aldershot, Hants, United Kingdom. [London Environmental Economics Center, University College London, London, United Kingdom]

"This volume is an attempt to give some structure to the concept of sustainable development and to illustrate ways in which environmental economics can be applied in the developing world." [from Preface]

Issues of capital stock, intergenerational equity, discount rates, and cost-benefit analysis are discussed in this book, which concludes with case studies analysing sustainable development in six different countries.

Pearce, D.W.; Barbier, E.B. and Markandya, A. 1988. Sustainable Development and Cost Benefit Analysis. Paper for Canadian Environmental Assessment Research Council, Workshop on Integrating Economic and Environmental Assessment, Vancouver, Canada. [London Environmental Economics Center, University College London, London, United Kingdom]

"This paper has the following aims: (i) to suggest a simple definition of sustainable development, (ii) to elaborate a set of minimum conditions for development to be sustainable, the conditions being based on the requirement that the natural capital stock be subject to non-negative change, and (iii) to show that these sustainability conditions can be integrated into, and modify, one of the most powerful economic paradigms at project and program level - namely the welfare economics underlying cost-benefit analysis.

The text of the paper sets out the basic ideas and reasoning. A mathematical annex illustrates the implications for cost-benefit analysis and project selection more formally." [from Introduction]

Pearce, D.W.; Markandya, A. and Barbier, E.B. 1989. Blueprint for a Green Economy. Earthscan Publications Limited, London, United Kingdom. [The London Environmental Economics Center, University College London, London, United Kingdom]

This report introduces the concept and ideas of sustainability. It begins with a broad definition of sustainable development, and then examines the relationship between sustainable development and the environment. Various methods for valuing the environment are outlined, as are different approaches to environmental accounting. Connections with project appraisal and aspects of discounting are also addressed. The final chapter focuses on prices and incentives for environmental improvements.

Pearce, D.; Turner, R.K.; O' Riordan, T.; Adger, N.; Atkinson, G.; Brisson, I.; Brown, K.; Dubourg, R.; Fankhauser, S.; Jordan, A.; Maddison, D.; Moran, D. and Powell, J. 1993. Blueprint 3: Measuring Sustainable Development. Earthscan Publications Limited, London, United Kingdom. [The London Environmental Economics Center, University College London, London, United Kingdom]

"Blue 3... returns to the UK... and looks more closely at the empirical evidence on the state of the UK environment, the UK's contribution to global problems, and the issue of how to measure sustainable development. It is a mixture of 'state of the environment' reporting and an update on the theory and measurement of sustainable development." [from Preface]

Pezzey, J. 1989. Economic Analysis of Sustainable Growth and Sustainable Development. Environment Department Working Paper No. 15. The World Bank, Policy Planning and Research Staff, Washington, DC, United States.

"This Appendix is not exhaustive, but it gives a good idea of the variety of definitions of sustainability concepts that have appeared in the last decade and of the people who use such concepts." [from article]

Prescott-Allen, R. 1995. Barometer of sustainability: A method of assessing progress toward sustainable societies. PADATA, Victoria, Canada and IUCN, Gland, Switzerland.

"This paper proposes a method of assessing and communicating progress toward sustainable societies. It is designed to be used at any level (local, provincial, national, international). Its essential features are:

* A model of a sustainable society that recognizes that people are a part of the ecosystem and that human wellbeing and ecosystem wellbeing depend on each other.
* An assessment framework derived from this model.
* A way of portraying a society's progress toward sustainability (the barometer of sustainability) that combines assessments of the ecosystem and the human system without trading one off against the other.
* An assessment hierarchy that strikes a balance between flexibility and comparability. It allows users to chose a manageable number of the most suitable indicators for their conditions and priorities. At the same time it provides a structure that enables different assessments to be compared." [from Introduction]

Rees, W.E. 1992. Natural Capital in Relation to Regional/ Global Concepts of Carrying Capacity. In: Ecological Economics: Emergence of a New Development Paradigm. Institute for Research on Environment and Economy, Ottawa, Ontario, Canada.

"This paper describes some of the conflicts between prevailing economic rationality and ecological theory that must be resolved if we are ever to achieve sustainable development. The overall purpose is to demonstrate some of the ways the emerging metadiscipline of Ecological Economics is addressing these conflicts. In particular, I explore the novel concept of 'natural capital' and show how it can be used in an instructive reformulation of the older ecological concept of carrying capacity. The resultant models of 'ecological footprints' and 'appropriated carrying capacity' present a serious challenge to prevailing assumptions about economic growth and present patterns of global development." [Introduction and Purpose]

Reid, W.V.; McNeely, J.A.; Tunstall, D.B.; Bryant, D.A. and Winograd, M. 1993. Biodiversity Indicators for Policy-Makers. A Contribution to the WRI/IUCN/UNEP Global Biodiversity Strategy. World Resources Institute, Washington, DC, United States.

"This paper sets out a framework for assessing conditions and trends in biodiversity at local, national, regional, and global levels. The framework is used to identify a minimum set of indicators necessary to meet the needs of a diverse audience of policy-makers - those associated with international nongovernmental organizations, intergovernmental organizations, and local governments, for example each with differing perspectives on and approaches to biodiversity conservation. These indicators can guide conservation decision-making by helping planners to set priorities, by influencing new policies, and by providing information to determine whether policy goals have been achieved.

The paper begins by reviewing the role that indicators can play in conservation and follows with a discussion of the approaches to measuring biodiversity. These include outlining what needs to be measured and some of the problems faced in attempting to measure individual biodiversity attributes. A set of 22 indicators is organized into three categories:

* indicators used to measure wild species' and genetic diversity
* indicators used to measure diversity at the community/habitat level
* indicators used to assess domesticated species (the diversity of crops and livestock).

The paper contains a review of the availability and the quality of the data needed to develop the indicators outlined in the text. It concludes with a discussion of how these indicators might be used for setting priorities for policy." [Abstract]

Robinson, J.; Francis, G.; Legge, R. and Lerner, S. 1990. Defining a Sustainable Society - Values, Principles and Definitions. Alternatives; Vol. 17, No. 2, pp. 36-46. [Department of Environment and Resource Studies, University of Waterloo, Waterloo, Ontario, Canada]

"The purpose of this article is to provide a working definition of sustainability that can be used to describe a sustainable Canadian society. This description will be

used to generate and test one or more scenarios of Canadian society over the period from 1981 to 2031." [from article]

Robinson, J. and Tinker, J. 1995. Reconciling Ecological, Economic, and Social Imperatives: Towards an Analytical Framework. Paper prepared for the International Development Research Institute, Ottawa, Ontario. SDRI Discussion Paper Series, 95-1. [Sustainable Development Research Institute, University of British Columbia, Vancouver, British Columbia, Canada]

"The extensive interactions among ecological, economic, and social problems discussed here suggests that none of these three groups of issues can usefully be addressed in isolation. The purpose of this paper is to outline one attempt to reconcile environmental, economic, and social goals. This paper proposes a single conceptual framework within which environmental, economic, and social objectives can be placed. It suggests how these different objectives might be reconciled, and discusses some of the problems such reconciliation poses.

This paper also discusses the need for a new analytical framework: a process by which local, national, and international policies may be evaluated to see how far they succeed in reconciling these three types of objectives. It critically reviews some existing analytical frameworks, and suggests some of the main criteria which a more adequate framework must satisfy." [from Introduction]

Rodenburg, E. 1995. Monitoring for Sustainability. In: T.C. Trzyna (editor). A Sustainable World: Defining and Measuring Sustainable Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

Monitoring for sustainability requires the creation of an *information system.* This article outlines such a system as containing problem definition, scale appropriate data collection, analysis, reports/indicators and decision makers reaction.

Rose, D.W. 1989. Agriculture and Forestry in the Context of Sustainable Development. Working Paper 5, Forestry for Sustainable Development Program, University of Minnesota, St. Paul, Minnesota, United States. [Department of Forest Resources, University of Minnesota, St. Paul, Minnesota, United States]

"Sustainability questions related to agriculture, forestry, the environment, and economic development have gained a great deal of attention in research and in public policy discussions. While technical solutions to achieve sustainable agriculture and sustainable forestry exist, additional research, extension, and education efforts are needed to bring about sustainable development in agriculture and forestry. Development of sustainable technologies is only part of a solution. Sustainable development will not take place unless an appropriate social, economic, and political environment is

created. This environment frequently does not exist and contributes towards a general decline in resource sustainability. Creating a favorable environment will require changing many existing agricultural, forestry, and other land-use policies throughout the world. Increased cooperation and coordination in research and in national and international policy decisions will be needed to halt the degradation of natural resources." [Abstract]

Smyth, A.J. and Dumanski, J. 1995. A framework for evaluating sustainable land management. Canadian Journal of Soil Science; Vol. 75, No. 4, pp. 401-406. [Four Seasons, Farnham, Surrey, United Kingdom]

"Concerns for the effects of global environmental change, caused primarily by the interrelated issues of environmental degradation and population growth, have prompted a consortium of international and national agencies to develop a Framework for Evaluation of Sustainable Land Management (FESLM). The FESLM, based on logical pathway analyses, provides a systematic procedure for identification and development of indicators and thresholds of sustainability. An assessment of sustainability is achieved by comparing the performance of a given land use with the objectives of the five pillars of sustainable land management: productivity, security, protection, viability, and acceptability. A classification for sustainability is proposed, and plans for future development of the FESLM are described." [Abstract]

Trzyna, T.C. (editor). 1995. A Sustainable World: Defining and Measuring Sustainable Development. Published for The World Conservation Union by the International Center for the Environment and Public Policy, Sacramento, California, United States.

This book, as its title suggests, focuses on definitions of 'sustainability' and 'sustainable development', and the challenge of measuring these. The first section contains four articles addressing the definitional issue, the second section examines progress made in the area of sustainability, and the third section focuses on indicators of sustainability.

van den Bergh, J.C.J.M. 1996. Ecological Economics and Sustainable Development: Theory, Methods and Applications. Edward Elgar Publishing Limited, Cheltenham, United Kingdom. [Department of Spatial Economics, Vrije University, Amsterdam, Netherlands]

"This book aims to give an account of the variety of available methods for integrated economic-ecological research, and to show how they can be applied and combined to deal with specific management and policy issues involving economic-environmental conflicts. Economic-ecological analysis is used here to refer to the description and analysis of systems of interactive economic and ecological processes, as well as the evaluation of management and policy options applicable to such systems.

This type of approach is especially relevant in cases where long-term processes are involved, since assumptions of fixed environmental circumstances are excessively restrictive then." [from Chapter 1]

van den Bergh, J.C.J.M. and Nijkamp, P. 1991. Operationalizing sustainable development: dynamic ecological economic models. Ecological Economics; Vol. 4, No. 1, pp. 11-33. [Faculty of Economics, Free University, Amsterdam, The Netherlands]

"This paper examines the implications of ecologically sustainable economic development for integrated dynamic modelling. After a concise discussion of sustainable development it is suggested that five concepts are central to it: intergenerational equity, the regional scale, multiple use, long-term uncertainty, and economic-ecological integration. The discussion of each of these issues is focused on the implications for model elements and uses. Thereby, old ideas are reviewed and new ones are proposed. The aim is not to come up with a rigid framework for dealing with sustainable development but rather to suggest which alternatives are available to deal with the central concepts, although in a section on economic-ecological integration general requirements for dynamic economic-ecological models are mentioned explicitly in order to offer a general frame of reference. These requirements are fairly general and may be taken up in ensuing discussions of the methodological aspects related to sustainable development." [from Abstract]

Van-Mansvelt, J.D. and Mulder, J.A. 1993. European features for sustainable development: A contribution to the dialogue. Landscape and Urban Planning; Vol. 27, No. 2-4, pp. 67-90. [Department of Ecological Agriculture, Wageningen Agricultural University, Wageningen, The Netherlands]

van Pelt, M.J.F. 1993. Ecologically sustainable development and project appraisal in developing countries. Ecological Economics; Vol. 7, pp. 19-42. [Wageningen Agricultural University, Wageningen, The Netherlands]

"This article examines how the concept of ecological sustainability may affect project appraisal for developing countries. It is argued that three criteria should be applied, viz. efficiency, equity and ecological sustainability. Operationalization of the sustainability criterion requires that policy-makers set targets for natural resource use. Moreover, they need to address new trade-offs, for instance between short-term income objectives (efficiency) and long-term environmental objectives (sustainability). The new issues raised by the sustainability criterion require a review of the applicability of project appraisal methods. Cost-benefit analysis (CBA) has been used most frequently, but its usefulness in sustainability-oriented project appraisal is shown to be limited. Despite some methodological problems, multi-criteria analysis (MCA) should be regarded as an appropriate alternative or complementary appraisal tool. MCA does not require monetarization of effects, nor does it exclusively focus on efficiency measure-

ment. These advantages apply particularly to developing countries where the data base is weak, economic activities are directly dependent on natural resources, and distribution concerns are strong. MCA may be applied to, inter alia, the estimation of scores on the sustainability criterion, and to the integrated evaluation of scores on the three key criteria." [Abstract]

van Pelt, M.J.F. 1993. Ecological Sustainability and Project Appraisal: Case Studies in Developing Countries. Ashgate Publishing Limited, Aldershot, Hants, United Kingdom.

This book begins with the basic concepts of sustainable development, from the perspective of developing countries. An overview of project appraisal phases and methods is given, and sustainability issues in the decision-making framework are examined, together with aspects of impact assessment, cost benefit analysis, and integrated evaluation. These concepts are then applied to two case studies: a forestry and environmental protection program in Colombia, and scenarios for Lake Burullus in Egypt. Finally, a practical framework for appraisal studies is outlined.

Victor, P.A. 1991. Indicators of sustainable development: some lessons from capital theory. Ecological Economics; Vol. 4, pp. 191-213. [VHB Research and Consulting Inc., Toronto, Ontario, Canada]

"Interest in sustainable development has prompted a search for suitable indicators that might complement or supplant the traditional measures of economic success. Although there is no agreement about the precise meaning of sustainable development, one idea which is increasingly in good currency is that sustainable development requires that the stock of capital that one generation passes on to the next be maintained or enhanced. Further, this stock of capital is seen by some to comprise two elements: manufactured capital and 'natural capital'. The extent to which these are believed to be substitutes or complements is one factor which separates the neoclassical school from some of its critics.

A premise of this paper is that if capital theory is relevant to sustainable development, then it should also be helpful in developing indicators. However, even within the normal confines of economics, capital theory is not a homogeneous body of analysis. Therefore, an exploration of capital theory and its relevance to sustainable development can be expected to generate various perspectives on those measures most useful for gauging the sustainability of economic activity. It is these linkages between capital theory in various schools of thought and possible indicators of sustainable development that are the subject of this paper." [Abstract]

World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press, Oxford, United Kingdom.

"...Our report, *Our Common Future* is not a prediction of ever increasing environmental decay, poverty, and hardship in an ever more polluted world among ever decreasing resources. We instead see the possibility for a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base. And we believe such growth to be absolutely essential to relieve the great poverty that is deepening in much of the developing world." [from Overview]

Yanarella, E.J. and Levine, R.S. 1992. Does Sustainable Development Lead to Sustainability? Futures; Vol. 24, No. 8, pp. 759-774. [College of Architecture, University of Kentucky, Lexington, Kentucky, United States]

"The shortcomings and contradictions of the present understanding of sustainable development as a concept and a strategy suggest that the very idea of sustainable development must be subjected to the most thorough-going reevaluation. In rejecting simplistic versions of sustainable development strategy, this paper offers the strategy of sustainable cities both as an alternative strategy and as a catalyst to long-term global sustainability. In so doing, it seeks not to replace all components of the strategy of sustainable development but instead to place them within a restructured strategic framework locating the design and building of sustainable cities at its center." [Abstract]

Zinck, J.A. and Farshad, A. 1995. Issues of sustainability and sustainable land management. Canadian Journal of Soil Science; Vol. 75, No. 4, pp. 407-412. [International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands]

"The concept of sustainability shows many facets. Ecologists, environmentalists, agronomists, sociologists, economists, and politicians use it with different connotations. In addition, the sustainability of land management systems varies in space, according to climate, soil, technology and societal conditions. Sustainable farming systems vary also in time, as they evolve and may collapse, frequently together with the corresponding sociosystems. Because of its complexity, sustainability is difficult to measure directly and requires the use of appropriate indicators for assessment. A good indicator is free of bias, sensitive to temporal changes and spatial variability, predictive and referenced to threshold values. Relevant data are often incomplete or inadequate for indicator implementation. To embrace the whole width of sustainability, several methods and techniques should be used concurrently, including land evaluation and coevolutionary, retrospective and knowledge-based approaches. It is, however, at the application level that major constraints arise. A sustainable land management system must satisfy a large variety of requirements, including technological feasibility, economic viability, political desirability, administrative manageability, social acceptability, and environmental soundness. Real world conditions at farm and policy-making levels need to be substantially improved to achieve sustainable land management." [Abstract]

Appendix: Approaches to Sustainability Assessment

1. Concepts of Sustainability

While the concept of sustainability is by no means new (Peet and Peet, 1990), it recently has become the subject of widespread debate and a voluminous literature. This emerged in the aftermath of the Brundtland Report, Our Common Future (World Commission on Environment and Development, 1987) which popularized the term 'sustainable development', defining it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". However many other definitions of sustainability and sustainable development have been proposed, such as those suggested in Pezzy (1989) and the Inter-American Institute for Cooperation on Agriculture (1991).

There may never be a single agreed-upon definition of sustainable development or of sustainability. With the pursuit of sustainable development now a de facto requirement of all public policy, it is in the interests of some to define the term narrowly, for example as 'environmentally-sensitive economic growth'. On the other hand, this report adopts the more commonly agreed-upon integrated view of sustainability, incorporating ecological, economic, social and institutional aspects. For example, Robinson et al. (1990) define sustainable development as "the persistence, over an apparently indefinite future, of certain necessary and desired characteristics of the socio-political system and its natural environment. Both environmental/ecological and social/political sustainability are required for a sustainable society."

What is 'sustainable' and 'unsustainable' within this broader context? If a coastal or watershed system is unsustainable, this is likely to be reflected in high levels of stress on certain aspects of the system. For example, the fish biomass may be falling precipitously, the infrastructure within local resource-dependent communities may be decaying, or the strength of local institutions may be insufficient to survive pressures upon them.

However, the existence of equilibrium is not a sufficient condition for sustainability. More important is how the system will adapt to change, since change is certain to occur at some point. Thus, resiliency is a key attribute; an equilibrium (whether stable or unstable) does not imply resiliency of the system. Thus a system with healthy resources and strong institutions to control exploitation may achieve an equilibrium but not be sustainable. Nor might one with a depressed but stable resource stock, and little pressure among users to exploit the 'uneconomic' resource. Nor might a system in which the harvest level is controlled (limited) by government. In the latter case, one might expect that eventually, either (a) fishers will find ways to thwart restrictions, with excessive harvests leading to stock decline (ecological non-sustainability), or (b) if high levels of control are exerted to avoid this, government costs will climb excessively (institutional non-sustainability). However, the system may be able to persist over a long period of time before a crisis develops, if a controlling 'heavy hand' can keep the system in an (albeit unstable) equilibrium.

2. Sustainability Assessment

The next concrete step beyond conceptual discussions lies in developing frameworks for analysing sustainability. It seems that most such frameworks view sustainability either in terms of its constituent components or in terms of its inherent attributes (properties).

Sustainability Components

In the 'components' approach, sustainability requires the presence, simultaneously, of each component. For example, Charles (1994) suggests four fundamental components:

Ecological Sustainability: maintaining resources at levels that do not foreclose future options, and maintaining or enhancing ecosystem capacity, quality and resilience.

Socioeconomic Sustainability: maintaining or enhancing overall socioeconomic welfare, measured as a blend of relevant economic and social indicators aggregated across the system.

Community Sustainability: sustaining human communities as valuable entities in their own right.

Institutional Sustainability: maintaining suitable financial, administrative and organizational capability over the long-term, as a prerequisite for the other components of sustainability.

Sustainability Attributes

In the 'attributes' approach, a set of desirable social objectives (the attributes) is first determined, and sustainability refers to a situation in which none of these attributes decreases over time, or alternatively, that a 'proxy' indicator for the set of attributes is non-decreasing (Pearce et al., 1990). Rees (1988) proposes a multi-faceted set of attributes:

Biophysical Environment:
1. Recognition of ecological boundaries and adaptive and interactive properties of ecosystems
2. Recognition of the need to merge human activities within natural cycles
3. Activity based primarily on renewable resources

Human Environment:
1. Satisfaction of basic human needs
2. Achievement of equity and social justice
3. Provision for self-determination

Political/Economic Institutions:
1. Long term perspective predominates
2. Multiple goals (social/environmental/economic)
3. Adaptive (institutions designed to respond and evolve...)
4. Responsive to crises at different levels
5. Systems oriented (awareness of interactions, tradeoffs...)
6. Interactive (open/fair/informed/empowering decision making...)

Whatever the framework chosen, a number of fundamental practical issues arise that must be addressed prior to carrying out a sustainability assessment. Some of these are described below.

Status Report versus Impact Assessment

Sustainability assessment in the context of aquatic systems may be focused on a present-day system or a proposed future activity. Specifically, we may wish to determine the current level of sustainability for an existing coastal zone or watershed, or to assess, a priori, the potential of a proposed management or development project (e.g. an aquaculture extension effort or a new coastal fishery) to enhance sustainability of the resource system. The first of these tasks requires a 'status report' (perhaps with measures of ecological and human carrying capacities) while the second evaluates possible 'impacts', expanding on analogous approaches in environmental impact assessment.

Setting Boundaries

How should the boundaries of resource systems be set for the purpose of sustainability assessment? Is it possible to reflect ecological, economic, sociocultural, institutional and political considerations simultaneously? If so, how? If not, which of these factors is of greatest importance in setting the boundaries? In this regard it would seem to be necessary to balance between the 'natural' delimitations of watersheds or coastal zones, on the one hand, and the de facto boundaries of the system from the perspective of the local human populations. In some cases, these two boundaries will match, but when they differ, is it more feasible to apportion ocean currents or water flow between human-defined areas, or to apportion people between ecosystems?

Sustainability vs. Non-sustainability

Are there any differences in approach required between the tasks of determining a system's sustainability versus its non-sustainability? It is quite likely that the latter will be easier to assess than the former (since crises are relatively obvious, whereas even a long-term equilibrium is insufficient to 'prove' sustainability). Hence it may be more feasible in practice to develop suitable indicators of non-sustainability than of sustainability. In turn, one might expect greater success in locating 'trouble spots' of

non-sustainability than in 'verifying' sustainability for a proposed activity. (This situation is not unlike the case of environmental impact assessment; it is not too hard to point to 'environmental crises', but considerably more difficult to determine whether as-yet-untried projects will be environmentally benign.)

The Need for Historical Comparisons

Forecasting the sustainability of a system must be based on historical comparison, to systematically determine which factors enhance sustainability and which are detrimental. Why was one system sustainable and successful, while another was unsustainable? However, since non-sustainable systems tend not to persist, there is an inherent difficulty in obtaining suitable time series of information to enable such an historical analysis. This is comparable to the assessment of species extinction rates, which is confounded by the fact that many species became extinct before ever being studied. The best hope may be to study currently problematic fisheries, where at least one component of sustainability has declined within recent history.

3. Sustainability Indicators

Within any process of sustainability assessment, sustainability indicators represent the measuring tools. For example, traditional discussions of sustainability in fisheries focused on maintaining the fish resource. The principal measuring tool was the 'maximum sustainable yield' (the maximum harvest that can be taken year after year without harming the resource), or more precisely the difference between this value and the current fish harvest. This indicator is certainly quantifiable, at least in theory, and provides a 'bottom line' for resource managers, summarized in a single number. (This is analogous to determining if a proposed project is economically feasible, based on whether the benefit/cost ratio is greater than one.)

However, a focus on sustainable yield ignores the many other components of fishery systems. Despite the long history of emphasis on sustainable yields, the idea of capturing the extent of sustainability in a single indicator seems unsuitable. Instead, modern discussions of sustainability adopt a larger view, broadening beyond single-species thinking to 'ecological sustainability', and taking into account the complex inter-relationships among socioeconomic, ecological and institutional factors. Thus, sustainability assessment takes on a quantitative and multi-faceted approach, based on checklists of relevant components, attributes and actions, and corresponding sets of sustainability indicators (Charles, 1997).

Within this broad context, development of sustainability indicators requires an agreed-upon set of sustainability criteria. The choice of such a set is critical to the analysis; it must presumably incorporate aspects of the ecosystem, the socioeconomic structure and the local communities, as well as the institutional integrity of the system. We can view sustainability as either the simultaneous achievement of all criteria on the list, or a suitable sub-set thereof. There are many considerations involved in the development of sustainability indicators, including the following:

Micro versus Macro Analysis

It can be argued that while the development of sustainability indicators to date has focused on the 'Macro' (national and/or international) level, there needs to be more emphasis on the 'Micro' (local, regional, community) level, at which development projects tend to operate. At the latter level, each locale has its own peculiarities, implying the need for both location-specific analysis and the search for commonalities. Comparability across the range of local experiences is needed, if broadly applicable conclusions, or even methodologies, are to be obtained. It is also important to consider how analyses of sustainability should differ, if at all, between 'macro' and 'micro' levels -- say between national-level plans on the one hand and watershed or community levels on the other.

Carrying Capacity

An important approach to quantifying sustainability lies in the concept of 'carrying capacity', a concept which is most well-established and most prominently applied in ecological studies. For any given population of interest, its carrying capacity is that population level that is sustainable indefinitely within the given environment (in the absence of exploitation).

The concept of carrying capacity is applicable not only to renewable resources themselves, but also to the human populations exploiting those resources. Indeed on a global scale, the concept is well-utilized in discussions of human population pressure on global resources, where debate relates to the planet's human carrying capacity. However, for the present discussion it is more relevant to note that in a coastal or watershed system, just as the natural environment determines the carrying capacity of the resource, so too does the socio-economic environment influence the 'carrying capacity' of human activity in the system.

While there has been relatively little research to date on integrating the human and biological aspects of carrying capacity in renewable resource systems, a number of approaches have potential:

1. Aggregated approaches focus on determining a single measure of the overall ecological carrying capacity for the human endeavour under discussion. An interesting variation on this (Rees, 1988) is based on the idea of an 'ecological footprint', the per capita human impact on usage of land and other resources in a particular ecosystem. This approach provides an indirect means to deduce how much human impact can be tolerated sustainably within the given area under question.

2. Disaggregated approaches (using the 'checklists' of ecological, socioeconomic, community and institutional sustainability, described earlier) could provide a set of indicators of socioeconomic, community and institutional carrying capacity, analogous to that of ecological carrying capacity.

3. Dynamic approaches move beyond the above 'snap-shots' of sustainability, assessed at a particular point in time, to focus on the dynamic adjustment processes involved in shifting a resource system between sustainability states (e.g. from one of non-sustainability, or one that is sustainable but unproductive, to a state in which sustainability has been improved). These are much more complex and data-intensive, but potentially of great practical importance.

The choice amongst these carrying capacity approaches will logically depend on data availability, the need to deal with temporal changes, and the capability for engaging in modelling efforts to address the development of sustainability indicators.

Validation of Sustainability Indicators

To what extent is a set of quantitative sustainability indicators useful in practice? This question can be addressed only through a process of validation. A cross-sectional study of a number of case studies must be carried out, with suitable contrast among the systems involved, across biophysical, ecological and human dimensions, and comparability across case studies. In addition, it is helpful to incorporate temporal information (time-series) in at least some cases, so that a comparison of adjustment dynamics can take place. In any case, however, it should be noted that there will always be some uncertainty about the utility of sets of indicators, since quantification of sustainability at the coastline or watershed level inherently requires projections into the future.

References

Charles, A.T. "Towards sustainability: The fishery experience." Ecological Economics 11:201-211 (1994).

Charles, A.T. "Fisheries in Transition." Ocean Yearbook 1997, University of Chicago Press, Chicago, U.S.A. (1997).

Inter-American Institute for Cooperation on Agriculture. "Toward a Working Agenda for Sustainable Agricultural Development." Paper DP-25, San Jose, Costa Rica (1991).

Pearce, D., Barbier, E., and Markandya, A. "Sustainable Development: Economics and Environment in the Third World" Edward Elgar Publishing Limited, Aldershot, U.K. (1990).

Peet, J., and Peet, K. "With people's wisdom: Community-based perspectives on sustainable development." Paper presented at the Ecological Economics of Sustainability Conference, May 21-23 1990, World Bank, Washington, U.S.A. (1990).

Pezzy, J. "Economic Analysis of Sustainable Growth and Sustainable Development." World Bank Environment Department Working Paper No. 15, World Bank, Washington, U.S.A. (1989).

Rees, W. "Defining Sustainable Development." School of Community and Regional Planning, University of British Columbia, Vancouver, Canada (1988).

Robinson, J., Francis, G., Legge, R., and Lerner, S. "Defining a sustainable society: Values, principles and definitions." Alternatives 17:36-46 (1990).

WCED (World Commission on Environment and Development), "Our Common Future." Oxford University Press, Oxford/New York (1987).