Sept. 1995 15023

Monitoring Environmental Progress

A Report on Work in Progress

Environmentally Sustainable Development

ESD

Environmentally Sustainable Development Series

Proceedings

Culture and Development in Africa: Proceedings of an International Conference
ESD Proceedings Series no. 1 (Also in French)

Valuing the Environment: Proceedings of the First Annual International Conference on Environmentally Sustainable Development ESD Proceedings Series no. 2

Overcoming Global Hunger: Proceedings of a Conference on Actions to Reduce Hunger Worldwide
ESD Proceedings Series no. 3

Traditional Knowledge and Sustainable Development: Proceedings of a Conference
ESD Proceedings Series no. 4

The Human Face of the Urban Environment: A Report to the Development Community
ESD Proceedings Series no. 5

The Human Face of the Urban Environment: Proceedings of the Second Annual World Bank Conference on Environmentally Sustainable Development ESD Proceedings Series no. 6

The Business of Sustainable Cities: Public-Private Partnerships for Creative Technical and Institutional Solutions ESD Proceedings Series no. 7

Enabling Sustainable Community Development ESD Proceedings Series no. 8

Studies and Monographs (formerly Occasional Papers)

The Contribution of People's Participation: Evidence from 121 Rural Water Supply Projects
ESD Occasional Paper Series no. 1

Making Development Sustainable: From Concepts to Action ESD Occasional Paper Series no. 2

Sociology, Anthropology, and Development: An Annotated Bibliography of World Bank Publications 1975–1993 ESD Studies and Monographs Series no. 3

The World Bank's Strategy for Reducing Poverty and Hunger: A Report to the Development Community
ESD Studies and Monographs Series no. 4 (Also in French, forthcoming)

Social Organization and Development Anthropology
ESD Studies and Monographs Series no. 6 (Forthcoming)

Related ESD Publications

Monitoring Environmental Progress: A Report on Work in Progress

Water Supply, Sanitation, and Environmental Sustainability: The Financing Challenge
Directions in Development Series

Toward Sustainable Management of Water Resources Directions in Development Series

Nurturing Development: Aid and Cooperation in Today's Changing World
Directions in Development Series

Monitoring Environmental Progress

A Report on Work in Progress

Environmentally Sustainable Development

ESD

The World Bank
Washington, D.C.

First printing September 1995

Library of Congress Cataloging-in-Publication Data

Monitoring environmental progress : a report on work in progress
p. cm.
Includes bibliographical references.
ISBN 0-8213-3365-8
1. Environmental indicators. 2. Environmental monitoring.
I. International Bank for Reconstruction and Development. II. Series.
GE140.M66 1995
363.7—dc20 95-30524
CIP

Contents

Boxes

Foreword

Most knowledgeable people working on environmentally sustainable development (ESD) know that the empirical base for decisionmaking is weak. At the World Bank we were very concerned that little was being done to improve the situation in ways that would respond to policymakers' concerns. Despite early work—including that of Ernst Lutz and Salah El Serafy within the Bank and Robert Repetto, Albert Adriaanse, and others outside—there was little prospect of policy relevant indicators even some years down the road. There are good reasons why the World Bank was and remains more a user than a compiler of indicators. Nevertheless, we considered the issue so important that we resolved to play a more proactive role by ensuring proper communication between users and compilers. To that end, we convened meetings and commissioned studies in particular areas. This report spotlights the brighter picture that is emerging for users, thanks to unprecedented collaboration among international agencies, national authorities, nongovernmental organizations, and academics active in this area.

As a user of indicators, the Bank's position is that more can and should be done with available information despite obvious imperfections and caveats. It is essential that policymakers have at least rough indicators of whether environmental conditions are getting better or worse, broadly. Making the most of what is available builds political support for appeals from compilers for additional resources.

There are important gaps in our understanding of the facets of environmentally sustainable development, but there are also areas in which data collection activities could be streamlined. Finding the right balance will require more attention to the gray area in which compilers' concerns about definitions of terms, sources and methods, and accessibility of nation-level data intersect with policymakers' pressing needs for guidance, even if based on imperfect information.

Monitoring Environmental Progress—the first in what is envisaged as an annual series—is a first step toward finding that balance. It showcases improvements in ESD indicators that help to analyze policy-oriented issues. Real improvement will depend on an unprecedented level of collaboration within the international community, dealing with more than indicators. Hence, while this publication is rich in "products" such as new indicators and innovative concepts, it is really about empirical processes.

The present Bank effort dates from the release of the Bank's *World Development Report 1992: Development and the Environment*. Andrew Steer, then core team leader for that report and now director of the Environment Department, supported efforts by the Socio-Economic Data Division to extend techniques for socioeconomic indicators to environmental ones. John O'Connor, then chief of that division, moved to the Environment Department to lead work on this report and on a broader knowledge base on environmentally sustainable development. This report is a part of this process, intended to foster international discussion.

Environmental indicators available today remain weaker than socioeconomic ones, which themselves are often highly flawed. This is partly explained by how recently environmental issues have come to the forefront in policymaking. That can explain, for example, why there is no internationally agreed framework for such indicators. As discussed in the appendix, good progress has been made on this front, and there are reassuring signs of a "common gene" in proposals for an indicator framework. Consensus seems to be forming around a table like the sustainability matrix in the appendix, in which issues are "rows" and key steps in moving from problem identification to problem solving are "columns." Issues can be viewed hierarchically, with concise measures like soil acidity nested in more general concepts like soil conditions, which are essential in broad issues like land management. There is reason to hope that, from a user's perspective, better frameworks, and agreed processes for improving and harmonizing them, will emerge from the materials presented at the April 1995 meeting of the UN Commission on Sustainable Development (CSD), including a draft of this report.

Closure on this broad methodological phase of work will reveal technical and analytical issues that create more fundamental problems in the environmental field than in socioeconomic ones. These will tend to require case-by-case review, at a national or local level, but an issue-oriented approach, such as that taken in the body of this report, does suggest some shared concerns. The theme of each chapter has been framed as a commonly asked question that decisionmakers, and the general public and technical experts, all can directly relate to, such as, "Can we save the forest while using the trees?" or "Are we sharing the burden of reducing climate risks?" This format, we believe, is helpful to lay the basis for common understanding of complex phenomena.

Our shared interest in such an issue-oriented approach is most apparent in the early chapters, which are concerned mainly with physical measures of natural resources. Indicators on forests, biodiversity, air, water, and material inputs in economic processes are considered. These examples were chosen not only for their intrinsic importance, but also because they provided good examples of how to promote a dialogue between users and compilers.

Three areas for improved communications emerge. There are questions about definitions (what is a forest? how should details about open forests and plantations be combined?). There are issues of methodology (how to blend remote sensing and ground surveys of forests, benefit-cost analysis, and sampling techniques). And there are practical considerations about the creation and maintenance of the massive data bases that will be required to come to grips with the complexity of interactions among ecological, social, and economic processes. Most relevant information is location-specific. Despite major advances in geographic information systems, this increased use of location-specific information still raises issues of aggregation and "ground truthing." Grappling with location-specific information can be viewed as a major headache for those responsible for information systems management—or as an opportunity for real progress on participatory processes and other forms of feedback on what works for sustainable development. Exploiting this opportunity will require compromises on the technical rigor of the construction of indicators but could prove invaluable to policymakers as a way to engage all stakeholders in deciding what the "facts" are.

The middle of this report delves into that gray area alluded to where physical indicators of environmental conditions blend into policymaking. Timely if imperfect indicators are needed, because policies are now being set in important areas. International conventions on issues such as climate change, biodiversity, and desertification require evidentiary processes. They seek quantifiable goals, voluntary targets, and other ways to monitor and evaluate performance. And many countries are reviewing not only their monitoring tools but also their policy instruments for suitability to the task ahead. Several chapters of this report (notably on taxes and subsidies, climate, and saving and wealth) therefore consider how a shared information system and clarity about the uses and limits of policy instruments might in turn help target indicator work.

We need to proceed quickly with similar work on all issues in the indicator framework, not only the nine taken up here. All are important, and many were omitted because they present even greater problems in deciding what the empirical base should be. More importantly, even more distilled indicators will be required to influence policymaking. The CSD Secretariat's documentation indicates that thought is being given to this problem. The need for a more analytical framework is clear. Provisional ones, like the matrix in the appendix, point out possible synergies among separate compilation efforts but do not adequately capture the dynamics of sustainable development.

Many leads are given in the pages that follow, but perhaps the most profound suggestion of intellectual retooling is in the final chapters, which propose a change in the role of national accounting. Short-cut methods may help flag not only countries but also particular processes, notably saving-investment dynamics, where poor measurement of environmental aspects can give distorted signals to decisionmakers.

Chapter 7 suggests that international rankings—say, by per capita income—would not be much affected by "greening" national accounts. But the refinements involved do lead to interesting policy issues, for example, in the area of domestic saving and investment. In addition interesting observations can be made about wealth creation and, ultimately, the net worth of countries.

Even crude estimates of wealth (chapter 8) highlight the importance of human resources in sustainable development. This is the most important form of wealth in most countries; more often than not it exceeds the sum of the other two components (produced or human-made assets and natural capital). Developing countries are less wealthy than advanced ones, per capita, but produced assets account for about the same share (16 to 20 percent) of their total wealth as in industrial countries. Such findings suggest that it is time to move beyond the notion that investment is only what is embodied in machinery and buildings. The conclusions reached herein support the viability of the proposition that investment in people, and capacity building in general, is crucial for sustainable development.

Considerably more work and more conceptual thinking are needed on these points. We must recognize the work done by the national accounting standard setters around the world who have brought their own intellectual rigor to the environmental debate through risk management assessment at the level of the firm.

Preparation of this publication has underscored that while further refinement of ESD indicators is certainly needed, we should not lose sight of the even larger steps that must be taken once countries begin to compile such indicators to replace the first approximations given here. The objectives must be to have an internationally agreed framework, with a set of indicators that are robust, discriminating, interpretable, and linkable to particular policy levers. Such indicators should be relatively inexpensive to construct and monitor and should be internationally understood in terms of definition, methodology, and interpretation. Even if they are only approximate calculations the first time around (as are many in this publication), they will be a first step toward providing decisionmakers with a better basis for assessing policy choices. Keeping these broader objectives in mind while grappling with more technical concerns about data sources and methods will require cooperation on a global scale.

Ismail Serageldin
Vice President
Environmentally Sustainable Development
The World Bank

Acknowledgments

This report was prepared by an indicator team led by John O'Connor and including Kirk Hamilton, Claudia Sadoff, Kerstin Canby, Arundhati Kunte, and Philip Bogdonoff. Major topical contributions were made by David Cassells (forestry), Andrew Bond (biodiversity), Christiaan Grootaert (poverty), and John Kellenberg (resource efficiency). The work was carried out under the general direction of Andrew Steer and Ismail Serageldin, who also provided inspiration and concrete suggestions on how to make the report a tangible expression of Bank support for the use of better and more empirical methods in the study of sustainable development.

Many others inside and outside the Bank provided important contributions in specific areas, valuable guidance in moving from general ideas to specific indicators, and help in describing analytical and statistical issues. John Briscoe provided key materials on monitoring water, as did David Hanrahan on monitoring air. Substantive input was also provided by Richard Ackermann, Dennis Anderson, Paul Armington, Jan Bakkes, David Berry, Ken Chomitz, Charles Feinstein, Donald Gilmour, Hemamala Hettige, Tord Kjellstrom, Bjorn Larsen, Kseniya Lvovsky, Grecia Matos, Don Rogich, Jeffrey Sayers, Iona Sebastian, and Anil Somani.

Preparation of this report was aided significantly by the contributions made by participants in a series of consultations and workshops. Apart from the collaborative efforts described in the appendix, a workshop of more than twenty expert users and compilers from international and national agencies as well as nongovernmental organizations provided detailed comments on the first draft in September 1994. A second draft was reviewed in January 1995 by a blue-ribbon panel of external advisers to the Bank's Vice President for Environmentally Sustainable Development. Copies were distributed to the CSD for comment in April. Advance copies were distributed to another 100 interested parties for review. Among the many useful comments, pivotal suggestions were made by Albert Adriaanse, Nancy Birdsall, Carter Brandon, Alan Hammond, Robert Repetto, Maurice Strong, Veerle Vandeweerd, Joke Waller-Hunter, and David Wheeler.

Young Kim designed the information management system and helped Philip Bogdonoff implement it to both produce the publication and enable it to evolve as the underlying database grows and generates "meta-data" on sources and methods. Donna Brodsky, Norah Davis, Yusri Harun, Julie Harris, Alicia Hetzner, Jeffrey Lecksell, Jocelyn Mason, Hawanty Page, Christian Perez, Beth Sherman, and Melody Warford provided editorial and related technical support. Tomoko Hirata designed the cover.

Abbreviations and Acronyms

CDIAC	Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory
CSD	Commission on Sustainable Development (UN)
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
DALYs	disability-adjusted life-years
EHI	environmental health indicator
EPA	Environmental Protection Agency (U.S.)
ESD	environmentally sustainable development
FAO	Food and Agriculture Organization (UN)
FSU	former Soviet Union
G	Gini coefficient
GDP	gross domestic product
GEF	Global Environment Facility
GEMS	Global Environmental Monitoring System
GIS	Geographic Information System
GNP	gross national product
ICP	International Comparisons Programme
IPC	industrial pollution control
IPCC	Intergovernmental Panel on Climate Change
ITTA	International Tropical Timber Agreement
IUCN	International Union for the Conservation of Nature
LSMS	Living Standards Measurement Study
NASA	National Aeronautics and Space Administration (U.S.)
NCI	natural capital indicator
NNP	net national product

NNP′	net national production adjusted to reflect costs of natural resources and global damage from carbon emissions
OECD	Organisation for Economic Co-operation and Development
OTA	Office of Technology Assessment (U.S.)
PIM	perpetual inventory model
RIVM	Dutch National Institute of Public Health and Environmental Protection
SCOPE	Scientific Committee on Problems of the Environment
SDA	social dimensions of adjustment
SEEA	system of environmental and economic accounts
SID	*Social Indicators of Development*
SNA	system of national accounts
SOTER	World Soils and Terrain Digital Database
SPM	suspended particulate matter
UN	United Nations
UNCED	United Nations Commission on Environment and Development
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNICEF	United Nations Children's Fund
UNSTAT	United Nations Statistical Division
U.S.	United States
WCMC	World Conservation Monitoring Center
WDR	*World Development Report*
WHO	World Health Organization
WRI	World Resources Institute
WWF	World Wildlife Fund

Dollars are current U.S. dollars.

INTRODUCTION

Making Environmental Data Useful to Policymakers

The World Bank views environmentally sustainable development from three perspectives: economic, sociocultural, and ecological.[1] The diversity of these needs and concerns suggests that there is no universally "right" or "wrong" policy path to achieve environmentally sustainable development. Moreover, given the inadequate state of empirical evidence regarding the impact of human activity on nature, technical experts rarely can provide policymakers with unambiguous advice about trade-offs among competing long-term goals. To escape this conundrum, policymakers, technical experts, and the public must all share both knowledge and responsibility. Open discussion of the fuzzy links among the indicators currently available and countries' most pressing current concerns is therefore an essential first step toward achieving environmentally sustainable development.

This first edition of *Monitoring Environmental Progress* picks up the central theme of the Bank's *World Development Report 1992*—the complementarity of economic development and environmental management. Economic development cannot be the enemy of the environment for long and remain sustainable. By the same token the best policies for environmental protection also help further economic activity. Good environmental policies are good economic policies—and vice versa. Fortunately, considerable knowledge and experience already exist for designing a program to make the world wealthier while preserving its environment for future generations. This report addresses a sequence of issue-oriented questions about the practical implications of this view of development.

A basic problem is that there is as yet no internationally accepted system of indicators for environmentally sustainable development. Indeed, only one of its three perspectives—economics—can be said to have a reasonably articulated indicator framework, the UN system of national accounts (SNA). This first edition of *Monitoring Environmental Progress,* therefore, concentrates on what is needed from various disciplines to devise a framework of indicators of environmentally sustainable development.

Future editions will recognize additional dimensions to making development environmentally sustainable. For example, the Canadian Institute of Chartered Accountants has put together several useful indicators of environmental performance in "Reporting on Environmental Performance."[2] In addition, to mitigate investor concern regarding environmental impact, many nations and international accounting bodies are grappling with the identification and measurement of business risks and indicators.

Institutional Context

As a follow-up to the 1992 UN Conference on the Environment and Development (UNCED), a number of international agencies, nongovernmental organizations, national authorities, and academic institutions are preparing empirical studies to increase the store of environmental information. Several, including the World Bank, are also involved in the long-term task of developing statistical reporting systems. The aims are both to satisfy national policymakers' need for information and to facilitate comparisons of environmental sustainability among nations.

The UN Statistical Division (UNSTAT) is coordinating efforts to reach international agreement on reporting systems. Most approaches stress the integration of environmental statistics with systems already established for the analysis of economic and social statistics. The first task, however, is to develop acceptable indicators of environmentally sustainable development. Indicators—derived from finer-scale data—are intended to have significance that transcends the properties of the underlying data for issues of wider concern.

A brief chronology of statistical reporting efforts suggests that an unprecedented coordination of approaches is already taking place. Before UNCED, the main international sources for environmental indicators were the *Environmental Data Report* of the United Nations Environment Programme (UNEP) and the biennial *World Resources Report* of the World Resources Institute. In preparation for UNCED, environmental statistics also began to be included in such standard references for socioeconomic indicators as the World Bank's *Atlas, Social Indicators of Development,* and *World Development Indicators* and the United Nations Development Programme's (UNDP) *Human Development Report.*

The emergence of "core" indicators of environmental performance in the reports of member countries of the Organisation for Economic Co-operation and Development initiated a post-UNCED wave of new indicators for environmentally sustainable development. And these publications are evolving. New products under active development since UNCED include an initiative by the United Nations Environment Programme (UNEP) to produce *Global Environmental Outlook,* which will feature a first-ever assessment of global fresh-water supplies as well as markedly improved empirical bases for assessing air and water quality.

In still another approach, the secretariat for the United Nations Commission on Sustainable Development (CSD) is considering its role in promoting a user-oriented framework for environmental indicators. In taking stock of post-UNCED work on information needs,[3] a comprehensive review of plans for improved indicators for environmentally sustainable development was presented at the April 1995 CSD meeting. In coming years a chronology of outputs will chart worldwide progress on these fronts.

Nongovernmental organizations also have been active in the dialogue about appropriate indicators for environmentally sustainable development. The International Union for the Conservation of Nature has focused on community based approaches, which hold great promise for effecting fundamental change but cannot soon be extended to formulate nationwide systems. The Earth Council is promoting links between local and national concerns by bringing indicator issues to the attention of national sustainable development councils, exploring such measures as an "environmental footprint" that could be applied as easily to cities as countries. Still others are conducting case studies of selected areas.

There has been particular interest in variants on the recently revised UN system of national accounts. The New Economics Foundation has devised a sustainability indicator for the United Kingdom. The World Resources Institute is synthesizing a number of national studies of natural resource adjustments to national accounts. The World Wide Fund for Nature and a project called Accounting for the Environment are both actively reviewing efforts (by the Bank and others) in this area.

In this unique climate of cooperative effort, some have spoken of a "common gene" uniting the pool of indicators for environmentally sustainable development. In the Bank's view the common theme is the emphasis on national decisionmakers' needs, which has resulted in an effective, issues-oriented approach to the problem of defining indicators and the shared belief that it is possible to squeeze analytic content from available information despite myriad uncertainties about both the quality of the data and the underlying assumptions.

Researchers universally caution against striving for a "magic number" that would pretend to capture the complexity of sustainable development. But a general movement toward aggregated measures for specific issues is necessary. This longer-term goal was endorsed at the January 1995 Workshop on Indicators of Sustainable Development, cosponsored by the Belgian and Costa Rican governments, UNEP, and the Scientific Committee on Problems of the Environment. Intermediate "composite" indicators of progress are already being tested as schemes for monetary and nonmonetary valuation. Preliminary results suggest that—at a minimum—these experimental approaches will be useful in promoting consensus about priorities for further work.

Summary of Contents

Monitoring Environmental Progress poses a series of compelling questions that properly targeted indicators for environmentally sustainable development should help to answer. The discussion, therefore, explores the strengths and weaknesses of available indicators and suggests avenues for developing new ones.

The selection of questions is not meant to suggest that these are the only or most pressing issues. They were chosen rather to illustrate how even the rough indicators that are now available can yield analytical insight and help establish near-term priorities for basic research, including data compilation and modeling.

Perhaps the earliest sign of progress in developing useful environmental indicators was the shift of attention away from forests as producers of commercial wood supplies to concern about the sustainability of wood supplies—which is now giving way to a focus on the ecosystem functions of forests. Such a shift requires the development of indicators much broader than those that measure wood supplies or that evaluate forests in terms of the commercial wood industry.

Chapter 1 suggests that progress has been achieved by using forest area and its loss as indicators of environmental health. But—as our continuing inability to make authoritative and timely statements about trends in deforestation amply demonstrates—this change has not yet been universally adopted. To give just one example, the most recent data on forests at the global level are those for 1990. Similarly too little is known about forest quality, and a finer grain of data is required to reach informed judgments in this area.

The usefulness of ecosystem indicators, moreover, extends beyond forests to other environmental concerns. Improved indicators for assessing the management of forest ecosystems, for example, would also strengthen the monitoring and evaluation of biological diversity (chapter 2), although the number of other factors involved in establishing biodiversity indicators makes it difficult to reach common agreement on appropriate action in this area.

An analytical framework is offered in chapter 2 to guide discussions of biodiversity and direct attention to the most relevant monitoring tasks. The aim is to help establish priorities for local action and decisionmaking, which should in turn lead to better site-specific indicators. The problem is that it is unclear how to summarize fine-grain information across disparate locations when the information collected is tailored to site-specific observations. Attempts to develop summary indicators of biodiversity are noted in this report, but the results represent possible applications only and were not derived from direct studies of biodiversity in individual countries.

Chapter 3 emphasizes the fact that excessive use of the ecosystem as a pollution sink is likely to undermine the health of ecosystems, impose constraints on economic development, and above all, jeopardize human health. With their improved prevention technology and better institutional capacity to address such problems, high-income countries have been better able than poorer nations to deal with the problems of air and water pollution. But bearing in mind the increasing morbidity and mortality associated with air and water pollution, developing nations also need to include environmental concerns among their top priorities and to target action where it will bring the greatest health improvements at the lowest cost. Chapter 3 therefore identifies key pollutants and the parameters for monitoring them.

Chapter 4 explores technology's role in keeping development sustainable and the degree to which economic processes use natural resources efficiently. Grouping countries by income level suggests that, when income rises, input of resources at the margin is reduced. But the signals are mixed with regard to countries' reliance on renewable or nonrenewable resources and their attention to waste.

Governments can encourage or discourage the rational use of natural resources through taxes, subsidies, or less direct approaches. By considering the key sectors of energy and electricity, chapter 5 shows that there is considerable scope for improvement in this area.

Chapter 6 discusses emissions of carbon dioxide and other greenhouse gases. Stabilization of carbon dioxide emissions is examined by considering which countries are adding the largest increments to the stock of carbon in the atmosphere each year. This is not a simple story. While several developing countries are among the largest incremental emitters, on a per capita basis their emissions are but a small fraction of those put out by rich countries. On the other hand developing countries are several times less efficient in their use of energy. As this discussion of the indicators for greenhouse gas emissions shows, an equitable sharing of global commons will not be easily achieved.

Clearly there is much more to nature than can be accounted for entirely in terms of monetary indicators. Valuing in situ natural resources solely as raw materials, for example, ignores their role in the earth's complex life-support systems. Nonmonetary weighting schemes have therefore been suggested for forests, biodiversity, nonrenewable resources, and aspects of the global commons. In each case this report links the ecological goal of conservation to the economic goal of saving, even if expressing the two in equivalent accounting terms is not yet possible. The emphasis on nonmonetary approaches is not, and should not be interpreted as, a rejection of monetary valuation schemes.

In fact, chapter 7 introduces Bank work on a short-cut approach to "green" national accounts that yields time series for some ninety countries. When used to refine studies of saving-investment conditions, these computations convey an important analytical message to environmentalists and economists alike.

While it is widely recognized that rich and poor nations must both save to accumulate wealth, it is suggested here that conventional accounts give policymakers, particularly in resource-based economies, an overly optimistic view of domestic saving rates. Apart from environmental consequences (excessive use of natural resources), miscalculation of the saving residual can lead to a mistaken view of how well a nation is preparing for its future. A new measure of genuine saving is therefore suggested.

Chapter 8 contains an attempt at measuring the wealth of nations—in part to emphasize that natural capital ought to be viewed as a factor of production, and as an increasingly scarce one at that. The empirical questions focus on measuring natural resources relative to produced assets and human resources and determining which countries have relatively rich or poor natural endowments. The overshadowing importance of human resources is also noted.

One approach to measuring wealth is the trial balance sheet. Using this approach this report suggests that natural resources should be viewed as scarce goods for which appropriate macroeconomic policies should be adopted.

The discussion of wealth emphasizes the relative and complementary importance of human capital, produced assets, and natural resources in today's world. It concludes that human capital is worth more than either produced assets or natural resources, but that natural resources are probably worth more than produced assets—even without taking into account nature's invaluable life-support role. As might be expected natural resources are far more important in developing economies than in high-income economies. More surprising is the observation that produced assets account for 15 to 20 percent of an economy's wealth regardless of the level of total per capita wealth.

Natural resources have been valued only as raw materials on the trial balance sheet. While prevailing market prices seem to have meaning for these items, monetization is only one form of valuation. In principle a global balance sheet should also take account of the value of the life-support functions of the earth, which would require more flexibility in approaching issues of valuation, weighting, aggregation, and so on. Some aspects (efficiency of input procedures, saving the forest while using the trees, and so on) can be linked to items on the asset side of the wealth balance sheet. The liability side seems more appropriate for recording use of the environment as a sink for pollution and waste. For practical reasons some items (biodiversity, global commons, and so on) may have to be treated as memorandum items for the present.

When issues discussed in the early part of this report give way to sectoral analysis and monetization is considered alongside other approaches to aggregation and weighting, a macroeconomic framework begins to emerge. To help policymakers, a variety of such measures need to be summarized and subjected to similar valuation procedures.

The overriding importance of human resources in a nation's wealth draws attention to the importance of investing in human capital, which leads to chapter 9 and a discussion of how the poor have fared. Recognition that poverty is multidimensional underscores the need for indicators that reflect such varied issues as income, health, basic needs, and environment. A fair number of country-level indicators are already available. But poverty is both a household attribute and an attribute of nations, and it is important that indicators capture the microeconomic-level interactions. With information on basic needs and environmental indicators relatively scarce at the household level, this should be a prime direction for future work.

Handle with Care

All cross-country data sets—and especially those developed for this report—must be handled with care. Cross-cutting exercises such as the present one can compound (or offset) the pitfalls inherent in compiling separate economic, social, and ecological indicators. At this early stage of data work, therefore, proposed nation-level indicators should be viewed as tools useful for compiling supranational, policy-oriented measures rather than for monitoring the performance of individual countries.

Using nation-level indicators for monitoring and evaluation runs into the difficulty that national averages, or national sums, relating to environmentally sustainable development, are misleading, even when compiled in strict accordance with internationally recommended methodologies. Technical variations in the aggregation and weighting procedures used to generate nation-level indicators from subnational data can have a significant effect. Invidious comparisons are almost unavoidable when large, ecologically heterogeneous nations are reported alongside small, homogenous ones. Bank staff are therefore exploring ways to systematize the collection of subnational details in larger nations.

Most issues are discussed here primarily in nonmonetary, or physical, terms. Yet it should be noted that the seeming objectivity of this approach is often illusory, hiding significant differences in the quality of the factors being summed or averaged. Wherever possible this report uses a dual approach, providing readers with practical examples of the difference between monetary and nonmonetary valuation schemes. Parallel use of monetary valuation is important if environmental issues are to be incorporated in the indicators commonly used for macroeconomic decisionmaking.

The choice of aggregation over valuation procedures also reflects our view of how best to deal with obvious differences between market theory and practice. For example, most economists agree that markets can equilibrate prices for such tradables as subsoil assets and produced assets but are less successful with "nontradables" like land and human resources. But while thorny measurement problems arise when valuing both tradables and nontradables, monetary and nonmonetary pricing schemes do in fact coexist—with different effects in advanced and developing economies.

This first report in the *Monitoring Environmental Progress* series focuses on baseline estimates with an eye on future monitoring requirements. Working to improve data quality, it should be possible to update all of the descriptive indicators discussed in this report at least annually. Particularly with respect to performance indicators, efforts will be made in the future not only to provide time series but also to reflect better the role of map-based and textual information in monitoring and evaluating environmentally sustainable development.

Readers interested in fuller explanation of the data underlying the present discussion are referred to the appendix and to relevant background materials. Bank staff working papers, now in preparation, document sources and methods, and consideration will be given to their separate publication (in electronic and hard copy form) to meet demand.

It should be emphasized that this first edition does not address such fundamental research issues as the carrying capacity or cleansing properties of natural systems. Nor does it take into account the extensive work done by the accounting and business professions. By raising questions of contingent liability and requiring that evaluations of environmental aspects of business activity be disclosed in companies' audited annual financial statements, those who set national accounting standards in Canada, the United States, and the

United Kingdom—along with the International Federation of Accountants—have extended debate about the environment to the level of the firm. The relevance of basic scientific concerns to political decisionmaking will emerge more clearly should this series of reports succeed in encouraging better use of the information already available.

Indicators and Policy

Since the appropriate scale and precision of indicators for environmentally sustainable development depend as much on the clarity of goals as on technical concerns, even crude estimates can help focus the debate. Discussion of "goals" is used here to mean the evaluation criteria that policymakers use, while "targets" are the evaluation criteria offered on technical grounds.

The tabulated data and derivative indicators in this report are intended to clarify both analytical issues and long-term policy goals. While they are not robust enough to guide policymaking at the national level, even crude indicators can shed light on overarching conceptual uncertainties. Crude indicators can, for instance, sharpen what has thus far been an academic debate about "weak" versus "strong" sustainability by clarifying the argument with regard to such specific issues as whether forests can be saved while using the trees and to such broad questions as whether there is scope for substitution among major forms of wealth.

In the future we hope to report progress in the areas of legal accounting and institutional development. The CSD is already taking some steps in this direction, by following through with examination of sustainable development law. The World Bank and other UN organizations such as the FAO, UNDP, and UNEP are providing technical assistance that supports legal and institution building for sustainable development.

In this sense we hope that we can monitor where national governments put good environmental policy into action by enacting environmental laws and regulations that support measurable environmental progress. For example, we might seek indicators of whether legislation includes principles embraced at the 1992 Rio Earth Summit, such as "polluter pays," "intergenerational equity," "environmental impact assessment," "public participation," and the "precautionary principle." Because enactment of good laws does not necessarily equate with implementation, some measure is also needed of, say, budgetary resources dedicated to environmental protection.

Conventional concepts of statistical technique and data quality are of little use in coping with such vast areas of uncertainty as, for example, not only how but even what to monitor and evaluate. For this reason *Monitoring Environmental Progress* offers a more eclectic approach to empirical evidence. Starting with the imperative that policy formulation cannot wait, it proceeds on the principle that conclusions must be drawn despite enormous weaknesses in the empirical base. The focus is therefore on results, based on the most important elements of technical documentation.

The technical discussion in this first report was included mainly to suggest near-term priorities for the compilation of more reliable indicators. Every effort was made to rely on the best evidence from specialized fields in producing this report. The limiting factor was more often the poor understanding of how distinct fields connect than any specific lack in the disparate standards of proof for each. To answer the questions raised here generally required information from many disciplines and therefore called for an experiment in blending the empirical bases from distinct fields and institutions.

Improving the accuracy of indicators for environmentally sustainable development thus depends less on improving the quality of data than on understanding the connectives among disciplines. At least as much attention must be paid to context as to the conventions and standards of separate disciplines; texts, maps, and charts are as important as tabulated data. But ultimately, success in making development environmentally sustainable will depend most on improving the dialogue between experts and nonexperts alike. This series is a small contribution to that end.

Notes

1. Mohan Munasinghe, *Environmental Economics and Sustainable Development* (Washington, D.C.: World Bank, 1993).

2. Canadian Institute of Chartered Accountants, "Reporting on Environmental Performance" (Toronto: Canadian Institute of Chartered Accountants, 1994).

3. See chapter 40 in United Nations Conference on Environment and Development, *Agenda 21* (New York: UNCED, 1992).

CHAPTER 1

Can We Save the Forest While Using the Trees?

Modern forest management is experiencing a paradigm shift away from a focus on the supply of industrial wood and toward activities to involve local communities in keeping their forest ecosystems sustainable. Saving forests means far more than sustaining wood production. Forests not only have a significant influence on the livelihood and well-being of the people who live in or near them. They also influence problems of worldwide significance that the United Nations Conference on Environment and Development (UNCED) has singled out for global action—protection of the atmosphere, protection and management of land resources, and conservation of biodiversity.

To preserve both biological diversity and cultural heritage, modern forest conservation and management seeks to protect watersheds and habitats. Local communities empowered to husband their natural resources can also support agricultural ecosystems and control their energy production. The first job of forest management institutions must therefore be to ensure that the integrity and viability of forest ecosystems are maintained.

Forest Management Indicators

Forest management today covers a broad range of areas and concerns and requires an extensive array of indicators for assessing progress. While conventional indicators—which focus on commercial wood production—continue to be useful, additional indicators need to be developed to measure progress across the complete spectrum of forest functions. Work on these new indicators cannot be delayed simply because conventional indicators are imprecise.

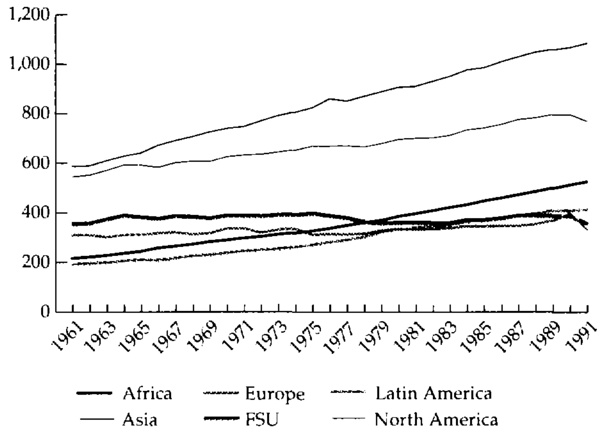
Trees: Continuity of Wood Supply

Continuity of available wood supply is one potential indicator of the sustainability of forest production. To date there has been no apparent diminution of the overall global wood supply, and global consumption of wood has continued to increase over the last several decades (figure 1.1). Yet many countries have experienced alternating patterns of boom and bust in wood exploitation. In some cases wood surpluses have been replaced by local and national shortages. In addition a significant proportion of current global consumption is still based on the harvesting of old-growth forests. The sustainability of current consumption patterns therefore needs to be carefully considered.

In this context the Organisation for Economic Co-operation and Development (OECD) has suggested using the ratio of annual harvest to mean annual increment (growth) as an indicator of sustainable wood production. Globally, current consumption patterns seem to be broadly in balance with the current supply capacity of the world's forests (figure 1.2). But projections also suggest

Global production of roundwood has continued to rise since the 1960s

Figure 1.1. Global production of roundwood, 1961–91
(Millions of cubic meters)



Source: Food and Agriculture Organization Agrostat data base.

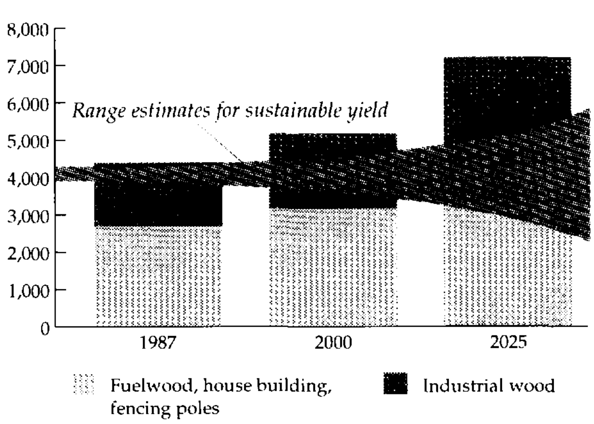
that, in the absence of interventions to increase forest productivity or to promote end-use efficiency, wood consumption could exceed the sustainable supply capacity of the world's forests within the next few decades.

Broad figures such as these, which cover all types of forests and wood products, mask problems with the local availability of products such as fuelwood or the continued global availability of various classes of wood products. There is also considerable uncertainty about the accuracy of the data and projections used in figure 1.2, and more sophisticated analyses are required to provide a reliable picture of the potential sustainability of world wood production and consumption. Available consumption figures, for instance, give no indication of the damage caused to standing trees by current harvesting activities or of the losses occasioned by disease, pests, pollution damage, or soil degradation. In addition, not all forests contribute to wood production. Some are better suited to conservation and other amenity uses or are physically or economically inaccessible for harvesting. Finally, the growth rates of both natural and planted forests vary enormously across regions, as do rates of deforestation and afforestation. In some areas the age-class distribution produced from current and past patterns of harvesting will, at least temporarily, disrupt the continuity of supply until the regenerating forests recover and grow a subsequent crop.

The use of broad, globally derived indicators of consumption and sustainable growth ratios is therefore likely to conceal more than it reveals (figure 1.3). To be sustainable, forest production must be practiced in the context of integrated land use, where an adequate permanent forest estate is maintained to provide environmental and amenity services as well as forest products. Detailed data on the net productive areas of various types of forest

At present use levels, global wood consumption may exceed sustainable global yield by the end of the century

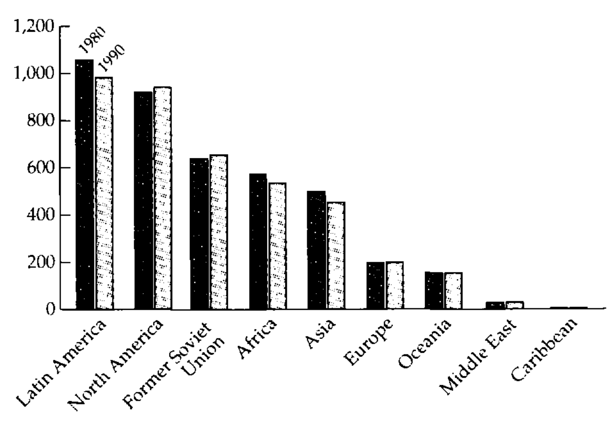
Figure 1.2. Projected global roundwood consumption and sustainable yields through 2025
(Millions of cubic meters)



Source: See appendix.

Changes in forests seem modest by regions, but this scale masks important local changes

Figure 1.3. Forested area worldwide, 1980 and 1990
(Millions of hectares)



Source: Food and Agriculture Organization, World Resources Institute, World Bank; see appendix.

are therefore needed. These data must then be combined with locally relevant stocking and growth data to produce meaningful estimates of the sustainable supply available from particular forest areas or regions. Remote sensing data can help, but the significant "ground truths" required to make them meaningful can be collected only at the national and subnational levels. Local and national reports then must be aggregated routinely to identify regional and global trends.

Comparison of projected supply and demand patterns for fuelwood, industrial timber, and other forest products can indicate pressures on forests, investment requirements for both industrial and nonindustrial needs, and likely shifts in trade balances and opportunities. But even more attention to coordination and standardization of data collection is needed to facilitate aggregation beyond local and national levels.

Forests: Sustainable Forest Management

Assessing sustainable forest management requires indicators of the total forest ecosystem, not just of the wood that forests can provide. Because all forest values depend on the continued existence of a viable forest resource, an important first-level indicator is the persistence of forest cover.[1] Forest area and change in forest area are the most familiar indicators used to signal levels and trends in forest cover, though the degree of uncertainty associated with currently available global estimates is not always appreciated. Many of these estimates are produced by statistical modeling, rather than by complete assessments of canopy coverage using data from satellite images, aerial photography, and on-the-ground inventories.

Evidence either of low levels of forest cover or of high rates of forest loss may signal a need for review of resource management policies, while sparse forest cover and high losses in combination are clearly cause for concern. But the definitions of "high" and "low" cover and loss must be country specific. Each country may achieve a different optimal percentage of secure forest cover, which will be determined by a complex blend of natural conditions and human demands. In some countries, forest conversion may still be unavoidable given the social and economic development objectives of growing populations. Only after careful consideration of the full spectrum of forest functions, including global externalities, can the optimal level of forest retention be determined. These levels can then be used as technical targets for assessing the performance of national forest conservation and management strategies and deciding how they fit into larger land use strategies and frameworks for international cooperation. Meanwhile, available indicators constructed against world averages rather than country-specific goals can still help to show basic trends and emerging issues.

Total forest area and the percentage change in a forest area, for instance, can throw light on a range of forest functions. The total area of forest cover is most relevant for describing global ecological processes such as the carbon cycle and for estimating productive wood stocks. But information is needed on the composition, condition, and management of the forest as well as on its extent. Such information is rarely provided in conventional forest cover assessments.

The percentage change in forest cover may be a better indicator than forest area alone for assessing such localized phenomena as water regulation and habitat preservation. For forests that are fragmented and cover only a small fraction of their original area, it is likely that many of their localized functions have been compromised. The extent of forest area that is unfragmented, that is in important watershed areas, or that is free of human disturbance would therefore be a more precise indicator of the forest's ability to provide these forest services. But, again, such detailed information is not readily available, and percentage change in forest cover is the nearest globally available proxy.

While the overall area of forest has remained essentially the same in the temperate and boreal latitudes over the last decade, substantial forest conversion has continued in tropical areas (see figure 1.3). However, in some areas overall forest cover figures mask significant local change. For example, in the area of the former Soviet Union the net forest area actually increased by some 2,260,000 hectares between 1980 and 1990. But in the same period, some 3,930,000 hectares of plantation forest were established, suggesting that at least 1,670,000 hectares of existing forest were lost or converted to plantations. Some of this loss, moreover, almost certainly occurred through inappropriate harvesting practices in fragile permafrost environments.

Forest data for the former Soviet Union vary considerably from source to source. The figures discussed above were taken from the World Resources Institute's *World Resources 1994–95: A Guide to the Global Environment*.[2] National inventory data for 1992 for the same region supplied to the International Institute for Applied Systems Analysis, however, suggest that the area under forest actually expanded by some 22 million hectares between 1978 and 1988, with only Belarus, Tajikistan, and Uzbekistan recording small decreases in forested area. Changes in inventory protocols and transfers of jurisdiction among ministries for some lands during this period decrease the reliability of the data. (Figures from the 1993 inventory had not been released at the time of this writing.)

Broad regional patterns can be made more meaningful by looking at the dynamics of forest change at both the national (figure 1.4) and subnational level [for data on tropical forests see Food and Agriculture Organization (FAO), *A Forest Resources Assessment 1990*].[3] Countries can be classified by level of concern based on the dynamics of their forest cover and losses relative to global averages. The countries with below-average forest cover and above-average levels of forest loss are clearly cause for concern. Countries that cause the least concern are those with above-average forest cover and below-average rates of forest loss. The intermediate cases between these extremes must be evaluated on a case-by-case basis taking into account local and national conditions.

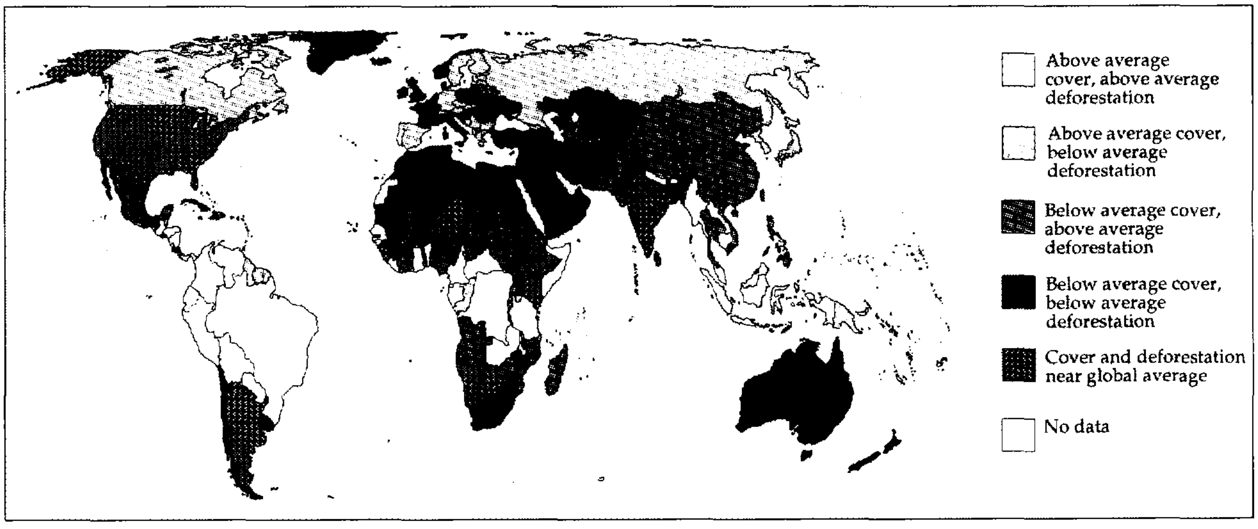
The extent of standing forest and the rate at which it is being cleared are critical measures of the state of the world's forests. National and global indicators of forest area and loss are, for example, useful measures for examining aggregate wood production capacities and such global ecological processes as carbon sequestration. They are also useful, although less so, in examining issues of biodiversity protection.

But forests are complex ecosystems that cannot be fully represented in terms of total area alone. Forests in different locations will support different volumes of biomass and different plant and animal species and provide different ecological functions. The condition and continuity of a forest area will largely determine its capacity to regenerate and to support wildlife.

Significant areas of natural habitat are necessary for the survival of both plant and animal species, and broad rules of thumb can be applied to determine whether global, regional, and national forest areas are sufficient. In the context of habitat preservation, however, it is crucial to know such details as the area of specific forest types (all of which support different species), the

Immediate action is needed to save sparse forests threatened by rapid deforestation

Figure 1.4. Extent of forest cover and rates of deforestation, 1980–90



Source: See appendix.

fragmentation of standing forests (to decide whether remaining continuous areas are sufficient for species survival), and forest condition (to determine whether secondary growth forests are too degraded to sustain species adapted to primary forest habitat). Useful indicators of ecosystem viability could therefore include the population of top predators in the ecosystems in question and the population status of species or groups of species that influence fundamental ecosystem processes such as nutrient cycling, seed dispersion, and pollination.

Regarding localized ecological phenomena, national-level indicators of forest area and forest loss are uninformative. To determine, for instance, whether forest cover can provide watershed protection or soil stabilization, information about the location of the forest cover is important. But national-level statistics equate the loss of 100 square kilometers of degraded forest with 100 square kilometers of forest cover in delicate watershed areas or unique habitats.

While the indicators discussed above are a useful first step, more refined indicators are badly needed. Such indicators would describe the condition of the forest in terms of standing tree volume, total biomass, soil nutrient status, and productive yield relative to managed forest stands and would include carbon budgets and population trends for migratory species. These indicators would also include assessments of the level of disturbance of remaining natural forests, the representation of forest ecosystems in viable protected areas, population levels of representative faunas, comparisons of natural and managed landscapes, the areas planted with indigenous species, and the proportion of representative provenances and genotypes conserved through adequate storage. Finally, forest indicators should include data on turbidity and siltation in waterways and on agricultural disruption. Opportunities also exist for integrative modeling with ancillary geographical information system (GIS) data layers on factors such as climate, edaphic conditions, elevation, and land use.

Refining forest assessment indicators means first of all finding better measures of location and specific forest type. Better assessment of these factors has implications not only for regeneration but also for the myriad ecological functions provided by forests because acceptable rates of global deforestation can mask devastating rates of deforestation in specific areas or forest types.

A range of rates can be seen, for instance, among regional, national, and subnational rates of forest loss. Between 1980 and 1990 the regional average annual rate of forest cover change varied from 1.2 percent annual deforestation in the Asia-Pacific region to net increases in forest area in some temperate regions (table 1.1). But national rates varied from a loss in forest area of 7.2 percent in Jamaica to an increase of 4.3 percent in Grenada. For moist tropical forest, the overall rate of loss was 0.8 percent. Small countries, even with high levels of change, had little impact on overall percentages, whereas even small changes in larger areas were of great global significance. For example, according to the FAO's *Forest Resources Assessment 1990*, just under 60 percent of all tropical deforestation between 1980 and 1990 occurred in just ten countries.

The Future: Forest Quality and Health

The basic indicators discussed so far describe the quantity of forests. What is needed are indicators by which to assess the quality and health of those forests. No such data have ever been gathered on an internationally comparable level.

Table 1.1. Annual rates of forest change, 1980–90
(Percent)

Rate of change (Percent)	*Africa*	*Asia and Pacific*	*Latin America and Caribbean*	*Europe and former Soviet Union*
Most recent rate for region	−0.7	−1.2	−0.8	0.1
Highest national rate of net decrease	−1.5 (Togo)	−3.9 (Bangladesh)	−7.2 (Jamaica)	—
Highest national rate of net increase	0.1 (Cape Verde)	0.0 (Singapore)[a]	4.3 (Grenada)	1.3 (Ireland)

— Not available.
a. Singapore has virtually no forest; all other Asian and Pacific countries have some level of deforestation.
Source: Food and Agriculture Organization, World Resources Institute, World Bank.

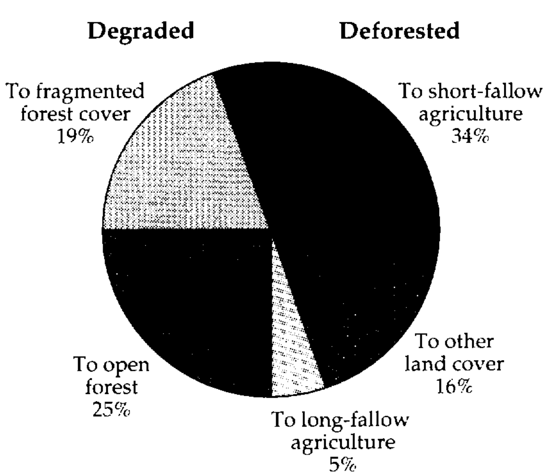
Attempts to address the issue of forest fragmentation, however, were initiated during the FAO's forest resources assessment in 1990. Preliminary data for thirty-one areas in Africa where multidate remote-sensing images were available were analyzed to describe changes in land cover in closed forest areas. It was found that 8.4 percent of the forest area had been subject to some change between 1980 and 1990. Roughly half of the area that was modified was converted either to short-fallow agriculture or to other land uses. But deforestation is only part of the story. The other half of the closed forest area that was modified was degraded to open forest, fragmented forest, or long-fallow agriculture (figure 1.5).

The clear loss in valuable forest ecosystem services is not reflected in current forest area and deforestation data. Degraded forests are not recorded as lost because they have not been deforested (by the definition in use). However, fragmented and degraded forests can provide only a small portion of the services provided by continuous closed forests.

In addition, damage from industrial pollution has affected large areas of ecologically delicate or socially significant forest in Europe and North America. The health of these forests can be described by a range of mensuration, biogeochemical, and visual indicators, which need to be refined for all types of forests to provide rigorous baseline indicators for monitoring forest health in newly industrializing countries.

Even though not totally deforested, 44 percent of Africa's harvested closed-cover forest is now fragmented or degraded

Figure 1.5. Use of African lands converted from closed forest cover, 1981–90



Source: FAO, *A Forest Resources Assessment (Tropical Countries) 1990* (Geneva: FAO, 1993).

These examples highlight the point that, while forest area and loss tell more about the forest ecosystem than wood indicators tell, they still reveal little about forest quality. Future data-gathering efforts must seek to address the functions and viability of forests by emphasizing such issues as forest location (for the preservation of areas, biodiversity, and natural forest regeneration), fragmentation (to indicate habitat continuity), integrity (to reveal the extent of human disturbance), and forest health (to reflect the impact of natural and human disturbances on the viability and productivity of the forest ecosystem). To assess such variables, a much finer grain of data is required, along with much greater emphasis on geolocation, surrounding land uses, and topography.

People: Social Sustainability of Forest Management

Forests are more than just plants and animals and the environment in which they grow and develop. Forest ecosystems have an important human dimension, which influences the future evolution of the forest community. But forests mean different things to different people.

To the people living in or near forests, they are an immediate source of the materials and shelter needed to ensure sustenance and survival. For others, forests are a source of timber and other commercial products that can be used to generate personal or national wealth. For still others, the most important value of forests is their role in protecting biodiversity and their influence on regional and global biogeochemical cycles. Finally, a large number of people value forests for their psychological or religious significance and regard their maintenance as integral to their personal and cultural identity.

Regardless of the particular view held, forests will be socially sustainable only if key stakeholders believe that conservation will provide them with more benefits than conversion to other land uses. But indicators of social sustainability vary with circumstances. At the local subsistence level, the most important indicators of social sustainability may be the per capita production of such forest products as fuelwood, fodder, and wildlife.

At both the local and national level, the most important indicator may be forests' contribution to employment and income generation. At all levels, an important indicator of social sustainability will be the opportunities open to all stakeholders to participate in the decision-making process affecting forests.

Indicators of social sustainability at the global level include the survival of the way of life of forest-dependent people, the number of countries that have signed international agreements on forests, and the strategies and action plans undertaken to meet these commitments. Another important global indicator of social sustainability is the level of funding that the international community can raise to preserve the global environmental benefits provided by forests. Unless forest conservation and management efforts receive such support, the local and national benefits of preserving closed-cover forests may be outweighed by the immediate tangible benefits of converting them to other land uses. In these circumstances, forest degradation and conversion will continue apace.

The UNCTAD case study of a Canadian logging and pulp processing firm[4] brings together social, environmental, and business issues and shows how one firm grappled with the need to consider both commercial realities and sustainable development. As a working principle, it was agreed that a sustainable ecosystem might not necessarily mean an unchanged ecosystem and that sustainable development might have different definitions. Company operations, accounting, and the natural resources on which the firm depends were reviewed over forty years instead of over the traditional annual accounting period. Defining the natural asset for which the firm would be accounting brought into focus the need to determine monetary values for trees and wood fiber as well as for habitat, wilderness, and genetic diversity. The company's focus on environmentally sustainable exploitation of forest resources may have put the firm at a competitive disadvantage. Scientists and other experts will have to agree on international industry practices so that compliance can have global benefits.

Policy Implications

While scientific and popular concern about the sustainability of forests is growing throughout the world, current indicators of sustainability are at best crude approximations of reality. Estimates of even straightforward indicators such as forest cover are both out of date and highly variable. The contrasting estimates of the forest areas in Russia are indicative of the level of uncertainty associated with even these basic parameters. We know little about regional or global deforestation that has taken place since the publication of the FAO's *Forest Resources Assessment 1990*. Immediate action is needed to make forest monitoring more reliable—and more than a once-a-decade event.

Available data suggest that deforestation in tropical regions has been accelerating with each decade, though some slowing in such key countries as Brazil may have occurred in recent years. More regular assessments of forest cover, using sequential satellite images and other continuous remote-sensing devices, are imperative for informed policymaking and for measuring progress toward environmentally sustainable development.

To describe the environmental performance of forest management, more detailed indicators are needed, including definition of the limits of acceptable change to ecosystem characteristics and processes. Generic performance indicators must also be developed to monitor achievement toward broadly defined sectoral management goals. And to define more specific indicators for monitoring performance toward particular project goals and for evaluating projects and adaptive forest management responses, environmental assessment and project planning are needed.

To this end, the Bank recently surveyed a wide range of forest management agencies and specialists on their use of performance indicators in environmental assessment. Information from this survey is currently being analyzed to improve the guidance given to Bank task managers on environmental assessment and forestry project management.

Finally, increased and directed international cooperation is needed to secure more comprehensive, reliable, and timely forest-indicator data for use by policymakers and stakeholders. Developing an expanded set of indicators must begin as a technical task for forest scientists and resource management specialists, but it should then expand to become a social undertaking. These indicators will provide yardsticks that the global community can use to measure its success in meeting its forest conservation and management objectives.

Goals for Forest Conservation and Management

In setting performance indicators, the definition of policy goals and technical targets must be clear. Stating goals or targets is often the only way to signal to compilers which of the many valid descriptive indicators for any area are important. But for forests and forestry, there is no internationally accepted set of global-level goals. Still, the United Nations Commission on Environment and Development's (UNCED) *Agenda 21* provides a starting point.[5] The first international consensus on global forests, it provides an accepted basis for future international cooperation on forest issues. UNCED conferences have led to international agreement on the importance of forests for both conservation and development and the critical principle that international discussions must focus on all forests, not just tropical ones.

However, UNCED forest statements do not translate general agreements on international directions for forest conservation, forest management, and forest-based development into specific targets around which resources could be mobilized and progress toward sustainable development could be documented. The setting of international targets could also assist individual countries to define meaningful national action plans. Setting goals or targets is therefore a prerequisite for meaningful discussion of international assistance to achieve conservation and management objectives.

The chapter on combating deforestation and article 11.4(d) in *Agenda 21* both stress the importance of maintaining existing forest in industrial and developing countries while sustaining and expanding the area under forest and tree cover in appropriate areas. In 1992 the Fourth World Congress on National Parks and Protected Areas suggested as a goal that protected areas should cover at least 10 percent of each biome by the year 2000. Two years earlier, producer countries that were members of the International Tropical Timber Organization had adopted as a goal the sourcing of all trade in tropical timber from sustainably managed forests by the year 2000—an objective reaffirmed in 1994 in negotiations for the successor to the 1983 International Tropical Timber Agreement (ITTA). Consumer country members, for their part, gave a formal undertaking to achieve sustainable management of their own forests by the year 2000. These undertakings could provide a starting point for work to define the more focused indicators needed to provide on empirical base for rational decisions on forest and other biome management at both local and national levels.

A goal of "demonstrable progress" could be defined as halving the 1980s rate of deforestation by the end of the 1990s and achieving a zero rate of deforestation (net of reforestation) a decade or so later. This would mean, as a first step, reducing global deforestation to a maximum of 8 million hectare per year by 2000. While even such a loose guideline would require more timely monitoring of forests, forest-cover indicators would not need to be precise until more precise targets or goals are accepted. Technical uncertainties about critical thresholds for harvesting forests and equity concerns about apportioning global goals among and within nations would remain.

On the latter point it interesting to note that the FAO's estimate of global forest cover of some 4 billion hectares is more or less evenly distributed between industrial countries in the temperate zone and developing countries in both tropical and temperate zones. Each half could benefit from a rapid assessment (say, by 1997) of the status of forest ecosystems to define priorities for these areas. This effort could be dovetailed with the FAO's plans for more frequent forest assessments. Each assessment might, for example, consider what would be required to incorporate a minimum core of 200 million hectares of forest in viably located, adequately sized, and appropriately managed protected areas—with due regard to the need to cover representative samples of all major types of forest, structural formations, and known areas of special biodiversity, habitat, or cultural significance.

Rapid assessments might also consider what can be done by the year 2000 to rationalize forest use outside the core protected area. As a way to focus the search for relevant indicators, operationally sustainable management might be defined using the criteria and guidelines adopted under the ITTA or under equivalent intergovernmental negotiations, which could be refined as more comprehensive international protocols emerge.

Any assessment would need to recognize the special role of tropical forests as habitat for a disproportionately high share of the world's biodiversity. Again, as a way to focus indicator work, it might be useful if rapid assessments considered what it would take to ensure that all temperate and boreal forests and at least an additional 200 million hectares of tropical forests outside the core achieved operationally sustainable management. To a large extent the targeting of this study would depend on a clearer understanding of the ends and means of monitoring biodiversity, discussed in chapter 2.

Setting broad, quantifiable goals would stimulate international thought and discussion on forests and forestry. These goals would obviously need to be reviewed carefully by stakeholders at all levels. But if even rough targets were adopted, individual countries and international institutions would be able to set national and institutional goals and would have some yardsticks for estimating the resources needed and for monitoring progress.

Many countries have already made voluntary commitments toward forestry goals under international instruments such as the Convention on Biodiversity and the ITTA. All countries now need to adopt forest policies that are relevant to local environmental and social conditions and consistent with contemporary international concepts of forest conservation, sustainable forest management, and sustainable development.

Notes

1. Forest cover is the area of land covered by various forms of forest ecosystems. The Food and Agriculture Organization (FAO) has adopted different definitions for tropical and temperate forests to match the characteristics of each region. In *A Forest Resources Assessment (Tropical Countries) 1990* (Rome: FAO, 1993), the FAO defines a tropical forest as an ecosystem with at least a 10 percent crown cover of trees or bamboo, generally associated with wild flora, fauna, and natural soil conditions and not subject to agricultural practices (p. 10). In *The Forest Resources of the Temperate Zones* (Geneva: UNECE/FAO, 1992), the FAO defines a temperate forest as land with tree crown covering more than 20 percent of the area (p. 340). For both tropical and temperate forests, closed forests are less precisely defined as forests where trees cover a high proportion of the ground and where grass does not form a continuous layer.

2. World Resources Institute, *World Resources 1994–95: A Guide to the Global Environment* (New York: Oxford University Press, 1994).

3. FAO, *A Forest Resources Assessment (Tropical Countries) 1990.*

4. United Nations Conference on Trade and Development, *Accounting for Sustainable Forestry Management: A Case Study* (Geneva: UNCTAD, 1994).

5. United Nations Conference on Environment and Development, *Agenda 21* (New York: UNCED, 1992). This document is a non-legally binding, authoritative statement of principles for a global consensus on the management, conservation, and sustainable development of all types of forests, issued at the Conference on Sustainable Development in Rio de Janeiro, 1992.

CHAPTER 2

What Do We Know about Biodiversity?

Earth's plants, animals, and microorganisms—interacting with one another and the physical environment in ecosystems—form the foundation of sustainable development. Biotic resources from this wealth of life support human livelihoods and aspirations and make it possible to adapt to changing needs and environments. The steady erosion of this biodiversity ... taking place today will undermine progress toward a sustainable society. Indeed, the continuing loss of biodiversity is a telling measure of the imbalance between human needs and wants and nature's capacity. (World Resources Institute, International Union for the Conservation of Nature, and United Nations Environment Programme, *The Global Biodiversity Strategy*, p. 1.)

When exploring indicators that might shed light on the conservation of biodiversity, the first step is to assess how well current management systems are achieving conservation objectives. The next step is to describe the present status of biodiversity, the current threats, the measures that can be undertaken to protect biodiversity, and the types of indicators needed on various scales to determine whether conservation objectives are being met.

Biodiversity—or the total diversity of living things on the planet—encompasses genetic diversity within species, diversity among species, and diversity of assemblages of species into ecosystems. Diversity in human cultures is also an important component because each culture represents a working solution to the problems of human survival in a particular environment.

The earth's biodiversity embodies values greater than those placed on it by the marketplace. But we cannot quantify many of the aspects we value most, such as genetic and species richness; ecological balance; recreational, commercial, and research opportunities; consumption benefits; and nonconsumption benefits such as aesthetic pleasure.[1]

Biodiversity interests have two monitorable foci. One relates to ecosystems and species in natural and modified habitats and the other to genetic diversity among species of current economic use. Economic viability requires maintenance of a broad enough base of livestock breeds and crop varieties to sustain economic activity in the long run. While managed ecosystems deserve equally detailed study, this chapter focuses on the ecosystems and species of natural and seminatural habitats.

Biodiversity Loss

Habitat loss is the primary threat to terrestrial biodiversity, which explains the present emphasis on protecting habitats (table 2.1). The root causes of habitat loss are varied but driven largely by human population pressure and demands for material goods. In roughly descending order of

Table 2.1. Protecting biological diversity

On-site protection		*Off-site protection*	
Ecosystem maintenance	*Species management*	*Living collections*	*Germplasm storage*
	Management systems		
National parks	Agroecosystems	Zoological parks	Seed and pollen banks
Natural research areas	Wildlife refuges	Botanic gardens	Semen, ova, and embryo banks
Marine sanctuaries	In-situ gene banks	Field collections	Microbial culture collections
Resource development	Games parks and reserves	Captive breeding programs	Tissue-culture collections
	Conservation objectives		
To establish a reservoir of genetic resources	To promote genetic interaction between semi-domesticated species	To maintain breeding stock	To provide a convenient germplasm source for breeding programs
To preserve evolutionary potential	To maintain viable wild populations for sustainable exploitation	To facilitate field research and the development of new varieties and breeds	To preserve germplasm of uncertain or threatened species
To preserve various ecological processes	To safeguard viable populations of threatened	To facilitate off-site cultivation and propagation	To maintain reference type collections as standard for research and patenting
To preserve species	To preserve species that provide important indirect benefits (as for pollination or pest control)	To maintain captive breeding stock of populations threatened in the wild	To provide access to germplasm from wide geographic areas
To preserve representative ecosystems	To provide "keystone" species with ecosystem support	To make wild species readily available for research, education, and display	To preserve genetic materials from endangered species

Source: U.S. Congress, Office of Technology Assessment, *Technologies to Maintain Biological Diversity: Summary* (Washington, D.C.: OTA, 1986).

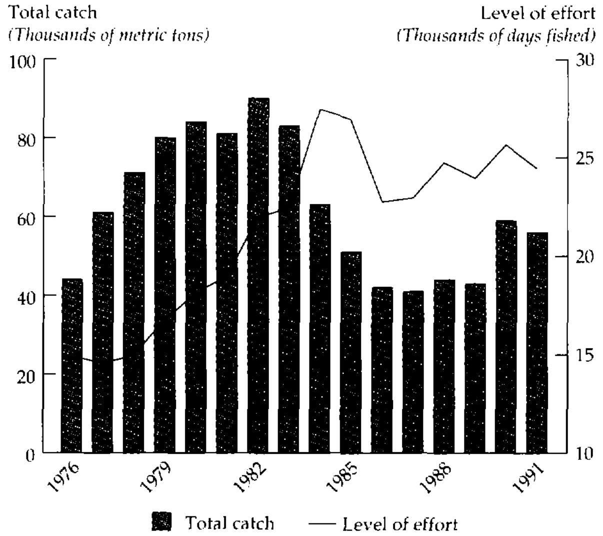
extent of impact, the main causes of habitat loss in land-based ecosystems are conversion for agriculture and settlement, logging and the establishment of tree plantations, and pollution. Where the remaining natural habitat is insufficient in size or too fragmented to support its previous ecological functions, effective losses often extend beyond the actual areas of conversion. In Africa, for example, forest fragmentation and degradation affected an area roughly equal to that deforested in the 1980s (see figure 1.5).

In the case of aquatic ecosystems, pollution and the introduction of exotic species play a more prominent role in both the destruction of habitat and the loss of species biodiversity. Commercial overharvesting of many freshwater and marine species is driving marine populations below the critical thresholds needed for species survival, and in some cases below levels required for the sustainable supply of food sources. Global estimates for total freshwater and marine catch increased up to 1992 (see FAO, *A Forest Resources Assessment 1990*).[2] But these gains masked regional declines and declines in the numbers of more commercially valuable species. The increase in catch can be attributed to increasing levels of fishing effort as improved technology and government subsidies brought down the cost of harvesting. But historical trends, such as those shown in figure 2.1 for Georges Bank, indicate that as harvesting effort has increased, total marine catch has declined. This means that productivity has been declining with increased investment. Fishing fleets work harder and longer trying to maintain previous levels of harvest, fish populations decline further, and fishing industry profits and marine species populations spiral downward.

More than 75 percent of threatened mammal species and roughly 60 percent of threatened bird species also face pressures of habitat destruction (figure 2.2). Hunting is the next greatest threat, followed by introduced species, illegal international

Increased fishing efforts only lead to smaller catches in New England's overfished waters

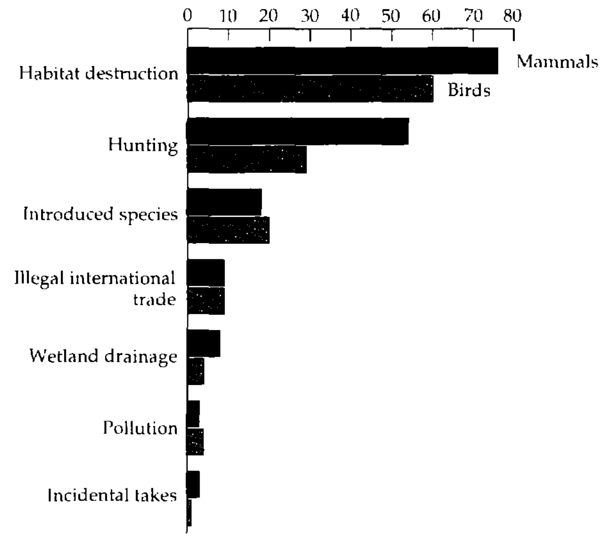
Figure 2.1. Comparing fish catch with harvesting efforts in Georges Bank, New England, 1976–91



Source: Northeast Fisheries Science Center, National Marine Fisheries Service.

Loss of habitat is the greatest threat to wildlife survival

Figure 2.2. Threats to the survival of mammals and birds worldwide
(Percentage of mammals or birds facing pressure)



Source: A. W. Diamond, *Save the Birds* (Cambridge: ICBP, 1987); J. Thornback and M. Jenkins, *The IUCN Mammal Red Data Book, Part 1* (Geneva and Cambridge: IUCN, 1982).

trade, wetland drainage, pollution, and incidental takes. Hunting, moreover, can occur at levels that will threaten biodiversity but not necessarily visibly disturb the landscape.

A Comprehensive Approach to Conserving Biodiversity

A comprehensive approach to conserving biodiversity, the Global Diversity Strategy, was put forward in 1992 by the World Resources Institute, the International Union for the Conservation of Nature, and United Nations Environment Programme in consultation with the Food and Agriculture Organization and UNESCO.[3] In addition to addressing the driving forces that underlie direct pressures, it considers the need to strengthen the tools and technologies of biodiversity conservation. At the international level, the following six components seem key:

- Protection of a representative range of ecosystems, sites with high biodiversity, and sites containing rare or endangered species within appropriately managed and adequately sized conservation reserves (on-site conservation).
- Management of surrounding areas to complement and amplify the conservation of biodiversity in adjacent reserves and within the protected area network (off-site conservation).
- Investigation of ways to integrate biodiversity conservation with the local use of natural resources into sustainable conservation and management strategies that benefit local populations.
- Establishment of off-site gene banks (in zoos and botanical gardens) to foster education, research, and the conservation of rare or endangered plants and animals whose wild populations face imminent threats of extinction as well as particularly useful species and varieties.
- Monitoring of pollution changes and conservation of selected indicator species both on and off reserve areas.
- Identification and modification of national and international policies such as subsidies that presently encourage the unsustainable use of habitats.

Biodiversity preservation is both a national and international concern. Pressures from population growth and increased consumption will continue, particularly in developing countries, where the majority of threatened species are found. Overexploitation of resources for local consumption and illegal international trade are particularly acute threats in less-developed areas, where local populations rely on hunting and collecting for supplementary nutrition and income. In such circumstances, knowledge of how protection will affect the income and social fabric of local populations and local participation in conservation projects are both prerequisites for successful protection. Once trained in sustainable resource management, local populations have a strong incentive to manage their natural capital with an eye to maintaining those environmental services on which their incomes depend.

International aid has been mobilized and conventions established to counterbalance the ill effects of commercial overexploitation and international trade. Multilateral lending agencies, including the World Bank, are placing increasing emphasis on investments that provide alternative economic opportunities that ease pressures on the environment. In extreme cases, the international community has sought to regulate or ban trade. The Convention on International Trade in Endangered Species of Wild Flora and Fauna, for instance, was signed by 113 countries.

Clearly, if conservation is a global goal, nations must cooperate and share the financial burden. To date international resolve has resulted in establishment of the Global Environment Facility (GEF), the Convention on Biological Diversity, world heritage sites, and biosphere reserves. At the same time, many countries are preparing individual strategy plans to meet the objectives identified in various treaties and conventions. A listing of these countries and their action plans would serve as a rudimentary indicator of the world's policy response to the problem of natural resource conservation.

Market forces have also been brought to bear. Consumer preferences for dolphin-safe tuna, recycled goods, and eco-labeled timber, for example, are encouraging demand-driven adjustments in production techniques.

On-Site and Off-Site Maintenance of Biodiversity

The 118 countries that had ratified the Convention on Biological Diversity as of April 1995 accepted protection of biodiversity as a global goal. But how best to achieve this protection is an open question. Various management methods are presently in use, ranging from on-site systems (such as wildlife refuges) to off-site systems (such as zoos and seed banks). Each has differing objectives and is part of a matrix of responses for biodiversity protection (see table 2.1).

Most biodiversity efforts have been directed at on-site conservation, which must continue to be the backbone of national and regional strategies. On-site protection provides a broad range of benefits. Protection of an ecosystem as habitat maintains such ecological processes as soil stabilization, watershed protection, nutrient cycling, pollutant filtration, carbon sequestration, and moderation of microclimates. It also allows for the evolution and propagation of species. Forest ecosystems with appropriate management can provide sustainable sources of income or income supplements in the form of fuelwood, construction materials, nontimber forest products, and ecotourism. When pollution and land-use pressures make on-site conservation uncertain or ineffective, off-site conservation is important as a form of genetic insurance for individual species.

Although it is generally recognized that ecosystem protection provides a broad range of benefits and opportunities for environmental research, outdoor recreation, and aesthetic enjoyment, many valuable natural areas are unprotected or protected only in name. While ongoing research continues to pinpoint the areas where the world's diversity is most threatened and clarify how it can best be protected, both on- and off-site protection are necessary.

Population pressures and land-use realities are such that the protected-area network by itself will not be sufficiently large or offer enough diversity to save many natural resources. Adjacent-site conservation efforts (establishing buffer zones around reserves and connections among primary habitat areas with the cooperation of local people) will be increasingly important to sustain viable populations of scarce and wide-ranging species.

In addition to delineating such management goals as forest protection or wildlife preservation, countries need to classify protected areas into ecofloristic zones. Ideally, systems of protected areas should be designed to cover a representative range of zones. Yet the distribution of protected areas is often skewed. Designation is frequently influenced by such social or practical considerations as ease of protection or competing land uses.

To the greatest extent possible, the distribution of protected areas by management goal and ecofloristic zone should be based on ecological principles. Protected areas should be representative of a country's species and ecosystems and sufficient in scale to sustain ecological functions.

Given a focus on policies related to protected areas and in situ conservation, indicators are needed to find out:

- Where the world's biodiversity is.
- How viable it is.
- Where the protected areas are.
- Where and why habitat loss is occurring.

For decision-making purposes—particularly where socioeconomic indicators are involved—map-based information must be simplified into tabulated data. Summary indicators based on ecological maps are emerging. A study in Indonesia developed a methodology to help set conservation priorities for West Kalimantan (box 2.1). But the data needed to compile such indicators for the whole world will not be available in the near future. Recognizing this, the Global Environment Facility and World Resources Institute published a method for computing a crude numeric national indicator of natural capital based on a country's natural areas, adjusted by the ratio of its actual and expected biodiversity (box 2.2).

Where Biodiversity Is

Because biodiversity is not evenly distributed, it is necessary to locate and map areas that are particularly rich in biodiversity. This process requires the use of proxy indicators. Ecosystems are increasingly used as the unit of analysis, since ecosystem maps can be compiled using limited information on vegetation and geology. Work in this area done by the World Bank, with financing and support from the Global Environment Facility and World Wildlife Fund, resulted in the classification of Latin America and the Caribbean into 191 ecoregions.[4]

Over time, ecosystem maps will be refined using geographic information on species ranges. Significant progress has already been made in collecting and organizing species data, particularly by Conservation International and its affiliates and by Costa Rica's INBio. One ongoing World Bank project is assembling species data for protected areas in the Indo-Malayan region and is also developing methodologies for deriving range maps from point observations of animals. Funded by the Dutch Ministry for Development, this study will enhance the existing biodiversity database management system. As part of another effort, the BioRap Project sponsored by the Global Environment Facility, a number of organizations—including Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO)—examined ways to use information on species distribution for more rapid ecosystem appraisal.

Viability of Biodiversity

One approach to monitoring ecosystem health is to use populations of indicator species as measurable surrogates for total biodiversity. Indicator species used for this purpose must be:

- Sensitive enough to provide early warning of environmental change
- Distributed over a broad geographic range
- Capable of providing a continuous assessment of stress
- Easy to collect, track, or measure
- Useful for differentiating natural cycles from trends induced by anthropogenic stress.

Birds are considered good indicator species because they occur in most land habitats throughout the world and are sensitive to environmental change. Both historical and detailed data on taxonomy and distribution, moreover, are more extensive for birds than for any other large group of animals or plants. Processes for data collection are also relatively well-developed in most regions of the world and are supported by extensive networks of volunteers. The World Bank and Bird Life International are presently experimenting with a joint exercise to exploit these advantages. But the correlation between high avian diversity and the biodiversity of other plants and animals varies according to region. Since no one indicator can be used to measure biodiversity, a set of complementary indicators (such as combining data on bird species diversity with plant or invertebrate species data, even where incomplete) is likely to be required.

Box 2.1. Conservation priorities in West Kalimantan, Indonesia

Considerable empirical evidence supports the assumption that forest and land-use type—reflected in the variety of tree species presented—is a meaningful proxy for the total biodiversity in an area. An easily defined surrogate indicator of total biodiversity (based on the limited data available) developed by Charles Peters was used to assess West Kalimantan's conservation priorities.

Peters's biodiversity index gives weights to species richness, endemism, and heterogeneity of the surrounding landscape. The index is based on geographic information pertaining to 2,610 geographic units, or polygons, about which there is some literature on land-use characteristics for different habitat types and geographic information system (GIS) analyses. Satellite imagery was used to identify the different habitat types in West Kalimantan.

Information on the estimated species richness of these habitats (based on available inventory data) is multiplied by the area of each habitat type (obtained from GIS analyses) to arrive at a habitat diversity index. A neighborhood diversity index was also estimated to reflect the importance of the biological richness of adjacent habitats. Finally, the endemism adjustment factor was estimated to show the degree to which the original vegetation had been disturbed. The sum of the habitat diversity and neighborhood diversity indices was multiplied by the endemism adjustment factor to yield a unique biodiversity ranking for each of the forty-five habitat types identified.

The methodology used is summarized by the following equation:

Biodiversity index = (habitat diversity + neighborhood diversity) x endemism adjustment factor

where habitat diversity$_i$ = log(SPPRICH$_i$A$_i$) and neighborhood diversity$_i$ = log(N_iSPPRICH$_i$). SPPRICH$_i$ is the species richness of the habitat type$_i$, A$_i$ is the area of the habitat type$_i$, and N is the number of adjacent habitats.

When developing conservation priorities, other factors in addition to biodiversity come into play. These may include the relative abundance of the habitat in question, the rate at which it is currently being transformed, and the extent to which similar habitats are already under protection. The measure of conservation priority to be accorded to a habitat type must take account all of these factors and must therefore be based on the habitat's relative rarity, transformation rate, and protection status. Rare, threatened, or unprotected habitats will therefore rank higher than more widespread or protected habitats in their need for immediate conservation.

While degree of protection and potential threat cannot be used in isolation to assign biodiversity values, they are useful for setting priorities for conservation efforts in light of the available options.

Source: W. B. Magrath, C. Peters, N. Kishor, and P. Kishor, "The Economic Supply of Biodiversity in West Kalimantan: Preliminary Results." Asia Technical Department Series no. 281. World Bank, Washington, D.C., forthcoming.

The following factors should be considered in selecting complementary indicators:

- Identifying indicators in poorly studied ecosystems is difficult, despite widespread use of indicator species in ecological science, forestry, wildlife management, and analyses of population viability. Some species are more important than others in helping to maintain ecological processes (for example, keystone species such as major herbivores, top carnivores, fruiting trees, and seed dispersers and pollinators of keystone tree species). By selecting indicators for the appropriate ecological process, conservation of species can be linked with conservation of critical processes.
- Since mammals and birds are easy to identify and sample and are often sensitive to a variety of disturbances, the recent trend has been to monitor indicator species that are important for a particular ecosystem process. For example, groups of species that make a living in a similar way (such as fruit-eating birds or ambush predators) can be used. Invertebrates, in particular select anthropods, are gaining popularity as indicators because of their diversity, environmental sensitivity, distribution, and availability for rigorous sampling.
- A hierarchical approach to selecting indicators is essential. Indicators are often identified at four levels of organization: regional, community, population species, and genetic. Indicators at the regional level, such as vegetation patterns, would have macroecosystem characteristics. Indicators at the community and population levels would include many different species. At the genetic level, easily assayed markers would be needed to indicate genetic diversity. In principle indicators should be integrated across levels, but such integration is not yet feasible.

The presence of an indicator species does not necessarily mean that the ecosystem under question is thriving. A forest may look intact temporarily, even though it has lost many of its

Box 2.2. A nonmonetary indicator of natural capital

The Global Environment Facility and World Resources Institute have developed a natural capital indicator (NCI) as a rough, nonmonetary measure of natural endowments for biodiversity. Natural capital is narrowly defined as the noncommercial portion of a country's natural resources, which the NCI assesses on the basis of biological resources on land, water, air, and coastal zones (including the exclusive economic zone) subject to data availability. The intention is to capture the value that is not reflected in conventional economic indicators. The indicator therefore includes forests, coastal zones, natural wetlands, relatively unmanaged rangelands, protected areas, protected watersheds, and any other areas that are left or managed in a natural state.

The NCI is based on a country's remaining natural areas (RNA) in hectares, adjusted by the biodiversity indicator (BDI), so that:

$$NCI = RNA \times BDI$$

where *RNA* is national territory less commercial lands and *BDI* is actual biodiversity divided by average biodiversity. *National territory* is defined as all areas (including land, freshwater, marine resource, and commercial land). *Commercial lands* are all lands temporarily or permanently under cultivation, plus permanent pasture, plus cities and metropolitan areas. *Actual biodiversity* is the number of species (mammal, bird, reptile, amphibian, and vascular plant) per area plus the number of endemic species (mammal, bird, reptile, amphibian, and vascular plant) per area. *Average biodiversity* is the global average number of species for a country of a given size.

In comparison, monetary estimates of natural capital focus on the commercial value of natural capital (see chapter 8). The two estimates, compared in the table below, show that even by such crude estimates, measuring natural capital is a two-sided proposition. To be comparable, the monetary values of land in developing and industrial countries must reflect vast differences in per capita income, while the nonmonetary value must reflect the far greater importance of land in developing countries as homes for biodiversity. Just as a monetary indicator must give value to things (notably to subsoil assets) that are correctly ignored by a nonmonetary indicator, so a monetary indicator omits biodiversity of no commercial value. The two estimates are therefore complementary.

Box table 2.2. Monetary and nonmonetary estimates of natural capital
(Percentage of global share)

Region	*Nonmonetary*	*Monetary*
Latin America and the Caribbean	28.6	8.7
High-income economies	21.5	67.8
Asia	21.0	1.9
Sub-Saharan Africa	12.6	3.4
China, India	7.8	1.0
Eastern Europe	7.0	13.8
Middle East and North Africa	1.4	3.5

Source: E. Rodenburg, D. Tunsall, and F. van Bolhuis, *Environmental Indicators for Global Cooperation.* GEF Working Paper no. 11 (Washington, D.C.: World Bank, 1995).

large fauna. Absence of the indicator species, however, usually means that the ecosystem's health is threatened.

Location of Protected Areas

Statistics on the extent of remaining natural habitat provide an indication of the state of biodiversity at the ecosystem level. Natural areas maintain high levels of biodiversity; converted areas, as a rule, do not. Figure 2.3 indicates the total global area covered by various biomes, the area of each biome subject to low and to high human disturbance, and the area officially listed as protected. While not all protected areas remain free of human disturbance and relatively high levels of biodiversity can occur outside protected areas, considering the relationship of protected to unprotected areas helps identify which biomes are under the greatest threat. It is therefore the initial assessment needed to establish global priorities for biodiversity conservation.

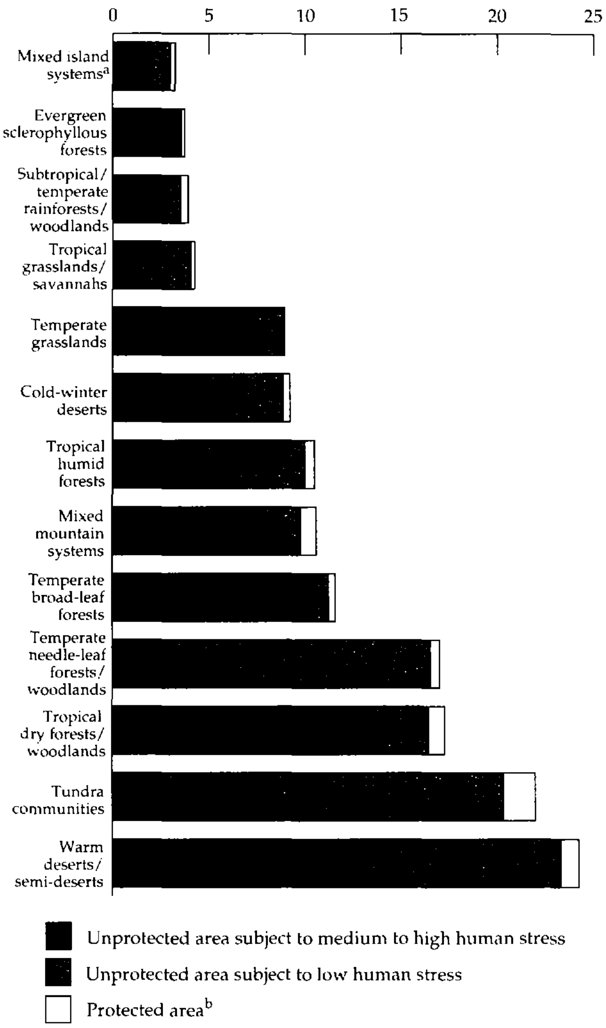
For example, although relatively few temperate grasslands are officially protected, over a quarter of their global area is relatively undisturbed. There are clearly many opportunities to establish further reserves. By contrast, while evergreen sclerophyll forests have a larger (but still modest) 4.7 percent protected area, only 2.8 percent of the biome outside these protected areas remains relatively undisturbed. This indicates an urgent need to set conservation priorities for these few remaining forests.

More than 5 percent of the earth's surface is currently designated as protected. But the extent, purpose, and biogeographical distribution of protected areas varies widely among regions and nations. Although the number of protected lands has increased dramatically over the last two decades, as available land becomes increasingly scarce, this upward trend will slow and could even decrease.

In the future, few countries will be able to designate protected areas as large as 1 million hectares, yet the larger the protected area, the

Biomes with a large proportion of land area that is unprotected and under high human stress, such as evergreen sclerophyllous forests, need emergency attention to ensure they are not lost

Figure 2.3. Which land types are protected, which are at risk
(Millions of square kilometers)



Note: Biome-type definitions follow the Udvardy classification scheme.
a. Includes marine protected areas and therefore may be high.
b. Assumes protected areas are under low human stress.
Source: World Resources Institute, *World Resources 1994–95* (New York: Oxford University Press, 1994), table 2, p. 153; and World Conservation Monitoring Center, *Global Diversity Status of the Earth's Living Resources* (London: Chapman and Hall, 1992).

greater the likelihood of sustainable protection of biodiversity. Smaller areas run a greater risk of becoming islands of undisturbed land hemmed in by crop-land and human-dominated areas. The resultant parks and reserves would be too small to hold viable populations of some of the larger carnivores and herbivores, and opportunities for species dispersal and for interbreeding only would require special wildlife corridors and management interventions.

Many countries have already collected information on the number and size of their protected areas and the quality of adjacent lands (figure 2.4). By adding data on ecosystem types and area needs of desired species, countries could evaluate the comprehensiveness and effectiveness of their national conservation systems.

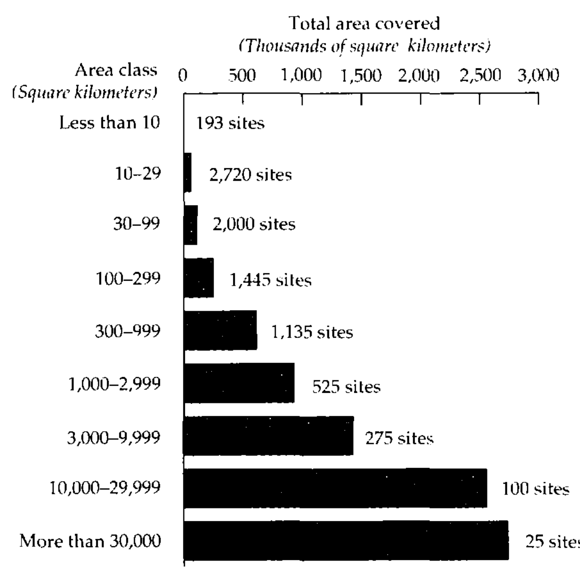
Effectiveness of protection is as important as adequacy of coverage. Many areas that are officially designated as protected or managed conservation areas are really just "paper parks." Illegal poaching, grazing, farming, and mining too often occur within legally protected parks. Effective protection not only requires well-defined and measurable goals, it also requires clear management mandates, local support and participation, and conscientious enforcement.

Shrinking Habitats

A focused policy for on-site conservation of biodiversity will obviously require that changes in habitats be mapped in relation to particular ecosystems and species ranges. Advances in the use of remote

Although biodiversity often requires large areas to be sustained, most of the world's protected areas measure less than 100 square kilometers

Figure 2.4. Number and size of the world's protected areas



Source: World Conservation Monitoring Center.

sensing have made this possible. NASA's Pathfinder Project and the European Union's TREES Project, for instance, are both engaged in the retrospective tracking of tropical forest changes worldwide. The FAO has used a sample-based approach to monitoring forest change and has proposed a continent-wide system to monitor African land cover. An increasing number of countries (many with World Bank support) are developing the skills and institutions needed to construct and maintain land-use information systems.

To understand why habitat lands are shrinking, it is necessary to relate projected effects of policies and socioeconomic scenarios on natural habitats and to understand the costs and benefits of different policies. Understanding of the forces behind habitat change has progressed beyond simplistic population pressure models and now includes many economic and social forces that drive both population distribution and land-use change. World Bank researchers, for instance, have been developing methodologies that use GIS data to predict the spatial impact of changes in infrastructure (box 2.3), land-tenure regulations, or commodity prices on land use and to calculate the opportunity cost (in forgone agricultural output) of putting areas under protection.[5]

The data needed for these projections are being made available through such initiatives as WRI's Country Data Sampler Series and the World Conservation Monitoring Center's (WCMC) enhancement of the policy relevance of its Biodiversity Map Library, which it is making operational in a joint effort with the World Bank. The implications of different scenarios—including long-term dietary developments and food prices—for global land-use patterns are now being modeled on a spatially explicit basis within the context of climate change.[6] Such models are promising tools for the assessment of conservation scenarios and policy options designed to prevent habitat loss and promote recovery.

Future Considerations

A number of new initiatives may lead to the development of national-level indicators of natural capital taking biodiversity into account. The Dutch

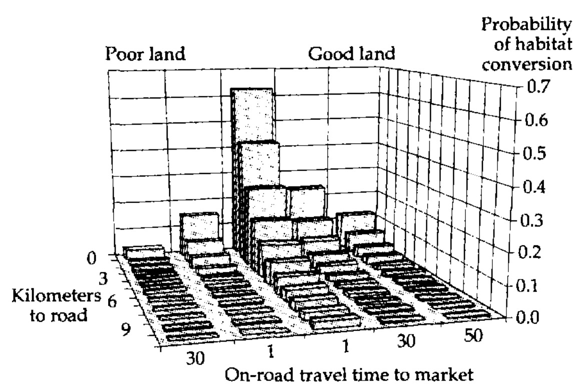
Box 2.3. Predicting habitat loss in Belize

Protecting habitats requires knowledge of where habitat is being lost, why it is lost, and how much is lost. This knowledge is particularly important in considering the layout of rural road networks, since roads are both a prime instrument for reducing rural poverty and a major facilitator of deforestation. Is there a way to design road systems to stimulate rural growth without compromising important habitats?

Chomitz and Gray have used economic geography to address this question. Through statistical analysis of geographic information system data, they examined how road access, market access, land tenure, and land quality affected the cropping and settlement decisions of commercial and semi-subsistence farmers in Belize. While classes of farmers were found to be sensitive to access, tenure, and land quality, commercial farmers were much more sensitive to market access and semi-subsistence farmers much more sensitive to such soil-fertility characteristics as pH and nitrogen content.

The results suggest that increasing the density of road networks near markets and near areas with good soils spurs land conversion. This may be an acceptable trade-off, moreover, where the resultant output gains are substantial, increased labor demand attracts migrants away from marginal areas, and near-town areas are of minor importance for biodiversity.

By contrast, road extension into remote areas caused habitat fragmentation without yielding significant economic benefits—especially where soils were poor. Extensions of this work in Belize and elsewhere will examine how changes in the road network, land tenure, or agricultural commodity prices shape changes in ecosystems and poverty.



Source: K. Chomitz and David Gray, "Roads, Lands, Markets, and Deforestation: A Spatial Model of Land Use in Belize." Policy Research Working Paper no. 1444. Policy Research Department, World Bank, Washington, D.C., 1995.

National Institute of Public Health and Environmental Protection (RIVM) and WCMC are investigating the available data to define a set of five coherent, summary indicators corresponding to essential concerns and taking into account biodiversity's effect on economic activity.[7] The World Resources Institute and other partners are developing a map-based indicator approach for assessing human pressures on ecosystems and the degree to which areas are at risk from continued human activity.[8]

In the future, the requirements of the guidelines for monitoring and evaluation of GEF biodiversity projects will have to be harmonized with the indicator mechanisms established for activities at the project level. Only then will they become a useful measure of natural capacity. Useful for this work is a menu driver linking management systems and conservation objectives (see table 2.1).

At the international and national levels, broad goals must be identified about which indicators will provide information. For example, a region or country could resolve to maintain a representative sample of ecosystems in viable protected areas and to adopt and implement codes of practice to support compatible and supportive ecosystems around protected areas. A process by which such goals could be translated into specific targets for the medium term (say, fifteen years) then must be developed.

Biodiversity indicators will be elaborated in three complementary directions. First, they will increasingly be based on geographically explicit data that reflect the critical importance of understanding exactly where biodiversity is located and what local pressures it faces. Second, they will have to be sensitive enough to measure performance. Integrated into economic and ecological models, biodiversity indicators will facilitate the examination of the ultimate impact of different policy scenarios. Finally, these indicators must serve as the foundation for a process by which broad goals can be translated into specific conservation targets for the medium term.

Notes

1. I. Serageldin and A. Steer, eds., *Making Development Sustainable: From Concepts to Action*. Environmentally Sustainable Development Occasional Paper Series no. 2 (Washington, D.C.: World Bank, 1994).

2. Food and Agriculture Organization, *A Forest Resources Assessment (Tropical Countries) 1990* (Rome: FAO, 1993).

3. World Resources Institute, International Union for the Conservation of Nature, and United Nations Environment Programme, *The Global Biodiversity Strategy* (Washington, D.C.: WRI/IUCN/UNEP, 1992).

4. E. Dinerstein and others, *A Conservation Assessment of the Terrestrial Ecoregions of Latin America and the Caribbean* (Washington, D.C.: World Bank, 1995).

5. W. B. Magrath, C. Peters, N. Kishor, and P. Kishor, "The Economic Supply of Biodiversity in West Kalimantan: Preliminary Results." Asia Technical Department Series no. 281. World Bank, Washington, D.C., forthcoming.

6. J. Alcamo, ed., *IMAGE 2.0: Integrated Modeling of Global Climate Change* (Dodrecht: Kluwer Academic Publishers, 1994).

7. B. Ten Brink and W. Douma, "Biodiversity Indicators for Integrated Environmental Assessments at the Regional and Global Level." RIVM Discussion Paper. Dutch National Institute of Public Health and Environmental Protection, Bilthoven, Netherlands, forthcoming.

8. D. Bryant, "The Ecosystem Indicator Model: Draft Concept Paper." World Resources Institute, Washington, D.C., June 1995.

CHAPTER 3

How Can We Monitor Air and Water?

It is a paradox of sustainable development that an alarming proportion of the world's population lacks access to reasonably safe air to breathe and water to drink, despite the abundance of these natural resources in the world as a whole. Since the quality of air and water is most crucial in areas of high population density, and since natural processes work in different ways in different locations, location and other qualitative aspects of globally abundant resources are of fundamental importance for purposes of monitoring and evaluation.

Economic growth and human development activities have resulted in an increasing deterioration of air and water quality to the extent that they now pose serious threats to health in many parts of the world. At the same time economic development seems to exert a positive influence on at least some forms of pollution. In order to understand the environmental impact of development and better target interventions, therefore, we must first devise fundamental measures of pollution and its impact.

Pollutants can be broadly categorized by their impact on human health, economic activity, and ecosystem functions and by their short- and long-run effects. Traditionally regulation of air and water pollution has sought to control damage from direct exposure. In both industrial and developing countries, concern for direct damage to human health has led regulators to concentrate on such air pollutants as suspended particulates, sulphur oxides, nitrogen oxides, and hydrocarbons. Regulation to prevent aquatic ecosystem damage has focused on organic water pollution and suspended solids. More recently there has been a growing awareness of the long-term impact of bio-accumulative compounds (particularly heavy metals) on the health of human communities and ecosystems. Even though valuation of the benefits is still difficult, the environmental policy community has clearly identified the early prevention of metals emissions as a regulatory priority for developing countries.

This chapter investigates measurement and impact-assessment methods, using as examples one direct pollutant—suspended particulates—and one bio-accumulative metal—lead.

A wide variety of pollutants are of concern for their health and environmental impact. At the same time the number of sources—industry, urban growth (especially transport), agricultural chemicals, and other human activities—is also increasing. But the link between the fundamental source of pollutant (an industry or an activity) and its ultimate health effects are complex and as yet poorly understood. In many cases this lack of understanding of the basic mechanisms makes monitoring and measurement problematic.

Information on pollutant sources is often available in broad terms where those sources are related to economic activity (industrial production, transport of goods, and so on). But the large number of intervening stages between source and effect creates uncertainty about the true nature of the relationship. Building a data base on ambient concentrations, a desirable objective, is often difficult, especially when data cannot be guaranteed for quality and reliability. In many cases the cost of improving the data, in both human and financial terms, would be high in relation to the value of the information obtained. This is particularly true of relatively localized problems, many of which may prove irrelevant to broader-scale indicators.

To assess air and water quality and refine pollution management measures in the long run, information is needed about sources, ambient levels, and health effects. But to maximize the impact of present actions, it is important to focus on a small group of broadly universal parameters that are directly related to health protection objectives.

Pollution Effects

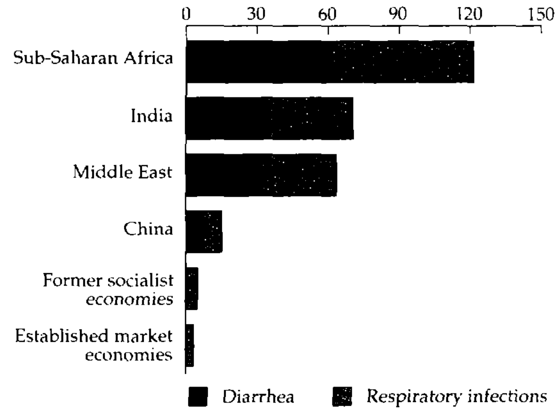
Several site-specific studies have examined health risks arising from pollution. Although results vary, some important findings have been consistent.

Major health problems identified have typically included respiratory problems due to air pollution (mainly particulate matter and, in some cases, very poor indoor air quality); lead poisoning from a variety of sources, but mainly from traffic-generated, airborne lead; and a range of microbial diseases related to water quality, hygiene, and sanitation. Mainly urban problems, they are by no means confined to major urban areas. Occupational exposures, moreover, are often much higher than the exposure of the population at large, endangering industrial workers, traffic police, and others whose normal activities place them in zones of particular risk.

Priorities vary across countries depending on the relative impact that air- and water-related diseases have had on human morbidity and mortality (figure 3.1). Statistics on the number of productive days lost (measured here as DALYs, disability-adjusted life-years lost) from respiratory infections and diarrheal disease suggest that in some areas (in Sub-Saharan Africa and India) water and airborne diseases hit with about equal force, while in established market economies, former socialist economies, and China, respiratory infections caused by polluted air are of far greater concern.[1]

While air pollution exacerbates lung disease around the globe, people in most developing countries suffer equally from waterborne infection

Figure 3.1. Bad air and water take a high toll on human health
(Disability-adjusted life-years lost per 1,000 people[a])



a. Present value of future years of disability-free life lost due to premature death or to disability in a given year.
Source: World Bank, *World Development Report 1993* (New York: Oxford University Press, 1993).

Based on this understanding of health issues, airborne particulates, lead, and the adequacy of safe water supply are the most immediate priorities for monitoring.

Air Pollution and Respiratory Disease

World Development Report 1992[2] identified suspended particulate matter as a major threat to human health. In the mid-1980s about 1.3 billion people—mostly in developing countries—lived in towns or cities that did not meet World Health Organization (WHO) standards for ambient levels of suspended particulates. It has been estimated that reducing pollution to levels that meet WHO standards could prevent 300,000 to 700,000 deaths a year. Even a slight reduction from present levels would result in significant health improvement.

The presence of suspended particulates in the indoor environment, while not as obvious, also affects air quality. In the dwellings of the poor in many countries, cooking fires, dust, and bacteria combine to threaten health far more seriously than was previously recognized. Evidence from limited and localized studies suggests that indoor health hazards can do more damage than those from outdoor pollution in the most affected urban areas.

Recent econometric studies show that a bell-shaped curve describes the relation of urban ambient concentrations of certain pollutants to such economic variables as GDP per capita. As an economy grows, air quality initially worsens (due to rapid industrialization and urbanization), then improves as higher incomes increase the demand for good health and environmental quality, which in turn induces the development of improved technology.

This observation has led some to suggest that development helps cure basic environmental ills. But with the fastest-growing nations—in economic and demographic terms—on the rising portion of this bell-shaped curve, increasing global pollution would have to be accepted as a given for the next several decades, with improvement coming only in the very long run.[3] In the interim, unless a more proactive policy stance is taken, the number of premature deaths and other negative health and environmental effects will certainly increase.

Particularly for low-income economies, therefore, where most of the world's population lives, it is crucial to find a better development path than traversing the entire length of the bell-shaped curve. With appropriate technology and supportive policies, these countries may be able to develop without going through the cycle of rising, then falling levels of pollution.

Aggregate-level indicators, even if inaccurate, can act as catalysts for breaking out of the historical pattern by bringing environmental concerns to the notice of the general public and demonstrating that appropriate policies can make a difference. Indicators of the state of air quality (state), the pressures generated by economic activity (driving forces), and the level of mitigatory action being taken (response) have a potentially important role to play in galvanizing country governments into action. Figures 3.2a and 3.2b provide an example, for suspended particulates.

Descriptive indicators of the state of air quality, in terms of suspended particulates, relate to ambient concentrations or to deposition. The most widely known data base on pollutant deposition levels is the Global Environmental Monitoring System (GEMS). The GEMS/Air project of the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) receives information on suspended particulate levels from monitoring stations in nearly eighty cities in more than fifty countries. (Other pollutants covered by the project include sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead.) To provide locational variety, monitoring and reporting are done separately for commercial, industrial, and residential locations. Reporting to GEMS/Air has been sporadic, however, and few country reports are available on a timely basis. (Box 3.1 discusses plans to improve the GEMS data base.)

Figure 3.2a is based on GEMS reports on ambient concentrations of particulates for a sample of cities and countries. Particulate deposition declines from low- to high-income countries, and except in low-income countries, airborne particulates decrease with time, consistent with the bell-shaped (or Kuznets-type) curve.

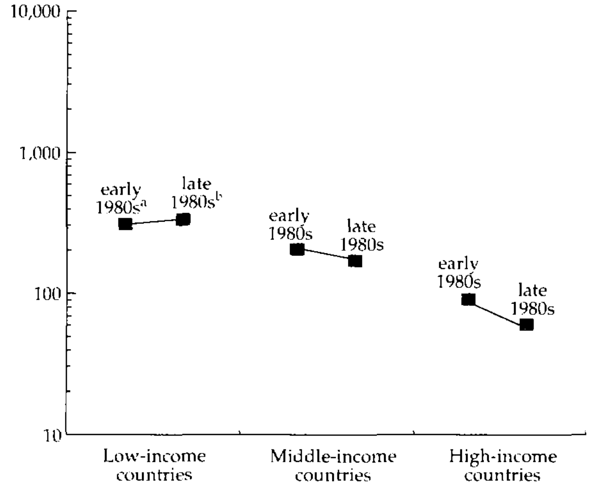
Most air pollution studies pay more attention to measuring ambient pollutant concentrations than to finding out how to reduce their generation. A shift in focus must begin with the identification of the forces driving pollution. Limited resources could then be directed to the monitoring of a few key polluters rather than to all potential sources. Developing indicators that give a rough sense of the magnitude of particulates being generated by economic activity may therefore be more solution-oriented than developing more refined mechanisms for monitoring ambient concentrations.

To look at the driving forces behind ambient concentrations, the World Bank has estimated the hypothetical generation of pollutants based on assumed emission intensities from different pollutant sources. Figure 3.2b gives crude estimates derived using this method of trends in particulate generation from mobile energy sources (mainly diesel fuel and gasoline) and from manufacturing.[4] These estimates consider pollution across country groups and over time, and particulate generation has been normalized relative to land areas. With similar emission intensities, the generation of suspended particulate matter increases across income groups. But over time (presuming unchanged technology), the predicted particulate generation has declined in middle- and high-income countries but increased in low-income countries, due to the changing character of their respective economic activity.

Hypothetical generation rates for scattered urban areas conform with deposition data for low- and middle-income countries, except where

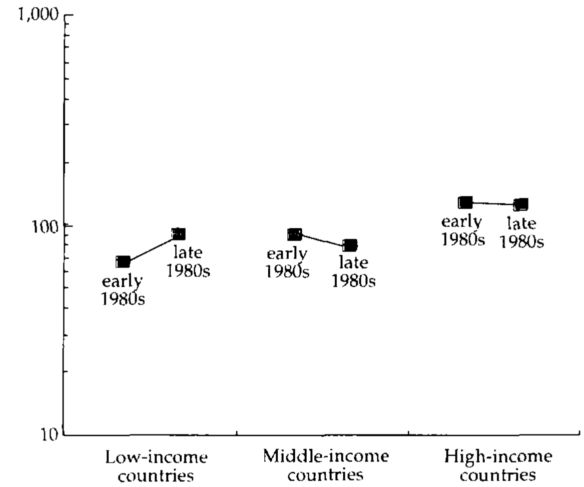
High-income countries emit high levels of particulates but have devised pollution controls to lower particulate concentrations in the air

Figure 3.2a. Ambient concentrations of particulate matter in a sample of cities in the 1980s
(Micrograms per cubic meter)



a. Average for data from 1979 to 1982.
b. Average for data from 1988 to 1991.
Source: GEMS/Air.

Figure 3.2b. Estimated particulate matter emissions in the 1980s
(Kilograms per square kilometer)



Note: A detailed explanation of the numbers underlying this graph is provided in Environment Department, World Bank, "The Generation of Suspended Particulate Matter," forthcoming.
Source: World Bank.

behavioral response has reduced actual generation rates. High-income countries, for instance, which—based on these estimates—should produce the highest level of particulate matter, in fact have the lowest deposition levels. The reverse is the case for low-income countries. This discrepancy cannot be explained by the environment's natural regeneration capacity, which affects both industrial and developing countries equally. Nor can it be a reflection of differences in economic activity, since these were factored into the driving force indicator. Hence the discrepancy most likely reflects pollution control interventions.

Assuming that the emission factors used to calculate these generation statistics are representative for low-income countries as a group, the ratio of deposition to generation for low-income countries can serve as a reference point for drawing inferences about the role of mitigatory responses. Such studies suggest that the difference in deposition-to-generation ratios across income groups and periods is attributable primarily to improved technology, good housekeeping, abatement practices, and the strategic location of industry away from urban centers—all of which affect real generation and are responsible for the low ratio in high-income countries. Although the analysis is crude, it nonetheless highlights the potential for policy responses to alleviate the problems of air pollution.

Even where driving force and state indicators exist, the evaluation of response may require quite different indicators. For instance, crude indicators suggested that a third of one city's particulate pollution was due to trash burning, a third to two-stroke engines, and a third to general industrial activity. Response indicators for the city might therefore include improved trash collection efforts, incentives to move to four-stroke engines, and the installation of industrial control devices. Where the World Health Organization's pollution guidelines are clearly exceeded by a wide margin, more precise measures of the driving forces and state of pollution have little relevance for policymakers.

Exposure to Lead

Lead pollution is caused by human economic activity (in contrast to particulate pollution, which can result from such natural nonanthropogenic sources as forest fires, volcanoes, and wind-blown dust). Human exposure to lead can come from air, food, drinking water, or contaminated household dust.[5] Lead has no benefits to the human metabolism, unlike other metals (such as copper and zinc),

Box 3.1 The Global Environmental Monitoring System (GEMS/Air)

Air pollution in urban agglomerations is recognized by *Agenda 21*[1] as an area where increased information and better understanding of the links between cause and effect are needed. Since many air pollution problems are local, regional, or at most continental in scale, moreover, no well-organized global inventory system currently exists.[2] The most widely known international data base, the Global Environmental Monitoring System (GEMS) of the United Nations Environment Programme and the World Health Organization, provides data on ambient concentrations as part of the GEMS/Air project.

Recent actions to upgrade GEMS/Air and promote the usability and relevance of air quality data will result in a reorientation toward integrated environmental assessment by the end of 1995 and in time for the 1996 Habitat II Conference. An expansion is also planned in the number and diversity of urban areas covered. The future GEMS would monitor emissions, ambient air quality, environmental management and air quality improvement programs and plans, general city information, and health and socioeconomic indicators (including projections). It is recognized that significant information gaps will exist for many (if not most) cities surveyed. One objective of the program is therefore to highlight these gaps and to promote the improvement of monitoring and evaluation systems.

But merely increasing the number of large cities monitored will not suffice. In the past, survey sites have largely reflected the health problems of people in urban areas. Further, a sample drawn from major urban areas (defined as having a population of more than 3 million) may not be representative of air quality encountered by urbanites in general. In 1992 only 36 percent of the urban population in low-income economies (and 40 percent in middle-income economies) lived in urban agglomerations of 1 million or more.

Stratifying the sample could go a long way toward correcting for this bias toward mega-cities. A cursory review of relevant World Bank programs suggests that there are perhaps 100 smaller cities where some air quality monitoring is already taking place. The possibility of stratifying the sample to include both mega- and smaller cities, as well as background estimates for rural populations, is being explored—keeping cost-effectiveness in mind.

With urban centers growing rapidly, there is a need to weight observations by population density, urban size, and other variables. International guidelines for weighting and aggregating such observations need to be developed. These and other innovative suggestions emerged at a December 1994 meeting on the future of GEMS/Air.

1. United Nations Conference on Environment and Development, *Agenda 21* (New York: UNCED, 1992).

2. Jan Bakkes and others, *An Overview of Environmental Indicators: State of the Art and Perspectives* (Nairobi: United Nations Environment Programme and Dutch National Institute of Public Health and Environmental Protection, June 1994).

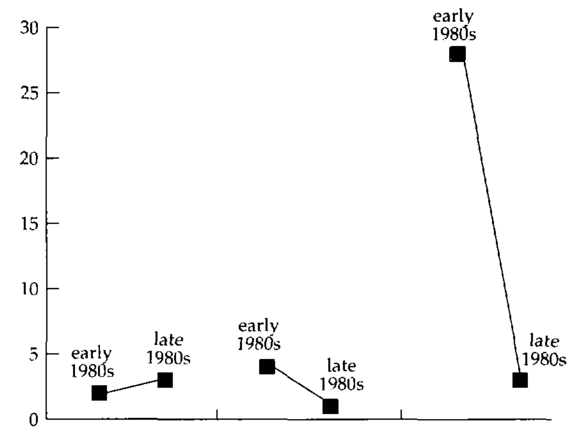
and has a negative effect on health, especially that of children. Studies demonstrate, for example, that exposure to lead is associated with a reduction in the measured IQ of children. Children are more susceptible than adults because they consume more food and water relative to their weight and therefore absorb a greater proportion of lead present. Food and water are therefore the primary exposure paths for children, while airborne lead is the greater threat for adults.

Exposure to ambient lead comes primarily from the use of leaded fuel in automobiles and from such stationary sources as primary and secondary smelters and battery recycling plants. In some large city centers, road traffic accounts for 90 to 95 percent of the health-threatening lead in the air. GEMS/Air monitoring sites frequently report on ambient lead, but experience indicates that even where generalized ambient lead levels are not high, localized lead levels in blood can be above safe thresholds.

Since airborne lead is the major issue for adults and leaded fuel is the primary source, focusing on the lead intensity of gasoline and the consumption of leaded gasoline provides a crude indication of the dimension of the lead problem. Data from the Natural Resources Defense Council for a sample of low-, middle-, and high-income economies show that lead in gasoline (based on total gasoline use and its lead content) has been brought down significantly in high-income economies (figure 3.3). The dropping of lead loads in wealthier countries reflects their extraordinarily high lead content in the past, before the adverse effects were clearly known. The major initiative for reducing total lead was the switch to unleaded gasoline, a move driven by social and political factors and not directly by economic development. This fact is reflected in the variability of effort seen among middle-income economies (figure 3.4). It is clear that industrial countries are generally taking

By regulating the use of leaded gasoline, high-income countries drastically cut their exposure to airborne lead

Figure 3.3. Lead concentrations in gasoline used in the 1980s
(Thousands of tons)



Note: The sample of middle-income countries was not representative; future efforts will be made to extend this data set.
Source: Natural Resources Defense Council.

action to reduce lead from gasoline use, but low-income countries are not. In fact, low-income countries' reliance on lead in gasoline may be increasing.

Scope for Improvement

This analysis illustrates the role of "optimally inaccurate" indicators. While there is scope for refinement in measurement, coverage, and weighting, rough numbers can amply illustrate the order of magnitude of a problem. Data on the state of air quality in specific locations, moreover, are useful for identifying trends despite lack of consensus over the best methods of measurement.

But decisionmakers must worry about the accuracy as well as the precision of indicators. National aggregation based on a sample of mega-cities needs to be qualified, for instance, especially where only a small percentage of urbanites in developing countries live in mega-cities. To determine exposure of the average resident to polluted air within a city, the issue of population density around monitoring stations and how to combine reports also needs to be considered. There is considerable potential, therefore, for upgrading hypothetical estimates of pollution generation and juxtaposing them with ambient concentration data.

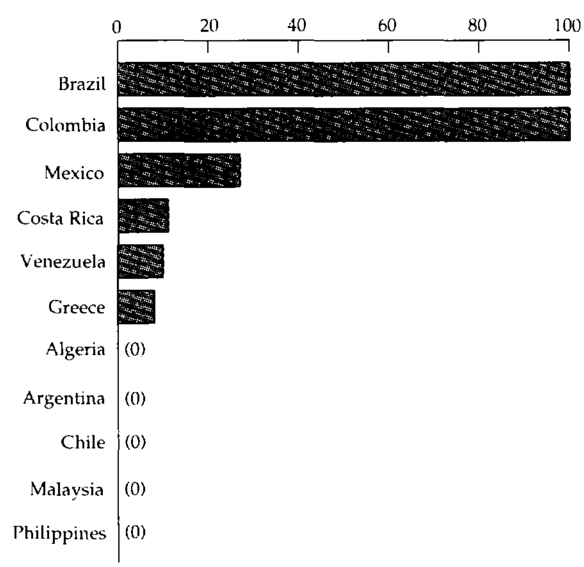
Nor is scope for improvement limited to such issues. There are a number of steps in the chain of causality from pollutant source to health effect, and data collection can take place at each stage (figure 3.5). There are initiatives to integrate information about the problem from pollutant source to health effects and remediation—notably the Decision Support System for Industrial Pollution Control, devised by the Bank with support from the Dutch National Institute of Public Health and Environmental Protection.

GEMS/Air focuses on ambient air quality in its attempt to provide comprehensive and compatible data worldwide. Instead of fine-tuning data and information at one stage of the causal chain, the possibility of spreading information-gathering efforts across the various stages should be explored. Proposed reporting on emissions by GEMS/Air would be a step in this direction.

In its ongoing work on environmental health indicators, the World Health Organization is seeking to link the environment and health in a single

Since regulation of leaded gas is a social and political rather than an economic decision, gas consumption in different middle-income countries varies significantly

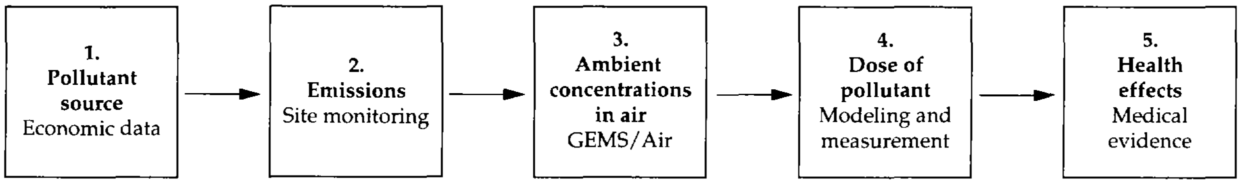
Figure 3.4. Decline in leaded gas consumption in middle-income countries in the 1980s
(Percent)



Note: The sample of middle-income countries was not representative; future efforts will be made to extend this data set.
Source: Natural Resources Defense Council.

The chain of causality leading to air pollution allows for data collection and interventions at each stage

Figure 3.5. How to build knowledge about the health impacts of air pollutants



measure called an environmental health indicator (EHI). Instead of looking at ambient concentration information and morbidity or mortality in isolation, such an indicator would combine the two.

Although scattered monitoring studies of stages other than ambient concentrations exist, it is difficult to ascertain the availability and reliability of these data. By contrast the availability of data on ambient concentrations is good. As noted earlier, GEMS/Air receives information from monitoring stations in nearly eighty cities in more than fifty countries and ensures its reliability through a certification process. But at present such certainty comes at a high price in terms of breadth and currentness of reporting.

Access to Safe Water

Water is unevenly distributed across world regions. Although it is extremely scarce in some arid zones, it appears in huge but intermittent volumes in tropical regions affected by monsoons and occurs in very large deposits in some inland lake regions. Sustainable development will therefore require different patterns of water use by different communities and for different economic activities. But for poor people everywhere serious health problems may be posed when access to clean water is costly.

It is becoming increasingly clear that access to water will be a major constraint on sustainable development in many parts of the world, and more work is needed on integrating water availability into socioeconomic analyses. Public water supply agencies are increasingly in competition with power companies and with irrigation, agricultural, and leisure users for the same scarce water resources. International and national water use planning and cooperation are increasingly important, as is the management of water quality. Water quantity is as important as water quality when considering the adverse impacts of waterborne disease since abundant water in or near the home is important for good hygiene.

Access to safe drinking water and sanitation are of immediate concern, particularly to the poorest of the poor. In 1980, the first year of the International Drinking Water and Sanitation Decade, targets were set for the degree of access to drinking water and sanitation to be achieved by 1990. But by the end of the decade—although some improvements in access to drinking water had been made—the same could not be said for sanitation facilities. Roughly 1.3 billion people still lacked access to safe drinking water, and 1.7 billion, predominantly in developing countries, lacked adequate sanitation. The consequences are manifest in high morbidity and mortality from waterborne diseases. Diarrhea and intestinal worm infections still account for 10 percent of the total burden of disease in developing countries, against a vanishingly small figure in high-income economies.[6]

These numbers raise doubts about whether access to basic services in the developing world is increasing or decreasing. Deficiencies in the data set and the potential for subjective definitions of such key concepts as "adequate amount" and "safe" affect the reliability of the indicators used (box 3.2).[7] There is also a problem of selectivity arising from the assumption that all government-supplied services are functioning and used, an assumption that fails to take into account self- and private provision. Official data that report on government-supplied services alone will be inaccurate where these services are not in use and people rely on private supplies.

It is increasingly being recognized that assessing access to water and sanitation is a multidimensional problem. Access to safe water is not only about being connected to a supply system but also about the quality and cost (broadly

Box 3.2. Problems in measuring access to safe water: The Côte d'Ivoire example

The example of Côte d'Ivoire illustrates the problems and inconsistencies in conventional efforts to measure access to safe water. All data presented in the two tables shown here come from World Bank reports.

Household survey data from Côte d'Ivoire found that only one-fifth of the population had access to tap water (box table 3.2a). The higher access rates that are recorded in *World Development Report 1994* and in *Social Indicators of Development* (box table 3.2b) suggest that many can get safe water from sources other than taps (such as from drinking wells or vendors).

But broader concepts of access to safe water raise new measurement problems, as is apparent from discrepancies between reports received directly from national compilers—the *WDR* column—and those processed by WHO—the *SID* column—(see box table 3.2b). Complex trade-offs between timeliness and standardization of reports are the reasons for the discrepancies.

Box table 3.2a. Percentage of population with access to tap water

Population	*1988*
Total	20.9
Very poor	2.9
Poor	11.4
Nonpoor	31.2

Source: C. Grootaert, "The Evolution of Welfare and Poverty Under Structural Change and Economic Recession in Côte d'Ivoire, 1985–88." Policy Research Working Paper no. 1078. Africa Technical Department, World Bank, Washington, D.C., 1993.

Box table 3.2b. Percentage of population with access to safe drinking water

Population	*WDR (1990)*	*SID (1987–92)*
Total	69	83
Urban	57	100
Rural	80	75

Source: Data in the *WDR* column are from World Bank, *World Development Report 1994* (New York: Oxford University Press, 1994). Data in the *SID* column are from World Bank, *Social Indicators of Development* (Washington, D.C.: Johns Hopkins University Press, 1994).

defined) of the service. Measuring coverage as the percentage of population having access to standpipes or house connections is therefore an inaccurate representation of whether people have access to safe water.

Apart from data-gathering difficulties, the analytical impact of such broad-gauge numbers as the number of people without access to safe water is arguable. They are nonetheless important for judging whether progress is being made, through World Bank loans and other means, in meeting the fundamental expectations of development. Such broad measures should therefore be compiled and updated from the kind of data used by water and sanitation specialists.

Toward Improved Indicators

In developing an improved and more useful set of water supply and sanitation indicators, certain important propositions should be kept in mind:

- The problem to be addressed is the quality of water supply and sanitation services that people receive, not whether they receive some service.
- Owing to the location-specific nature of the problem, indicators must be built from the bottom up.
- A single measure of global adequacy, quality, or cost of service is not analytically useful.
- A graduated system of indicators is needed, so that countries can collect information that is appropriate to their individual level of development.

Essentially, there is a need for more micro-level detail in assessing water and sanitation services. Table 3.1 shows the various categories of information of potential interest to different stakeholders, with an "x" indicating likely interest by a particular stakeholder. A third dimension, spatial differences, also needs to be addressed. Since urban and rural areas can have dramatically different options and problems in the quest for an adequate water supply, their information requirements will most likely differ.

Level I Indicators: Service Quality and Cost

Quality in water services includes proximity; reliability; the physical, chemical, and bacteriological composition of water; and cost in time and resources. Specific indicators relate to the different aspects of quality and cost. Some indicators can also be classified as referring to an aspect of access (A), safety, (S), or neither (N).

The quality of water can be measured in terms of:

- Perceived quality of water (S)
- Whether water is boiled before drinking (S)

Table 3.1. Information required to assess water and sanitation sector performance

	Stakeholder			
Information category	*Customer*	*Utility*	*Financing agency*	*Government*
I. Service quality and cost (household level)	x	x		x
II. Technical and financial performance (utility level)		x	x	x
III. Environmental quality				x

Note: Information needs will most likely differ in urban and rural areas.

- Supply location relative to the house (A)
- Average number of days a month water is available (A)
- Average number of hours a day water is available (A)
- Average time that pressure is adequate for in-house piped supply (A)
- Type of supply (N).

The cost of supplying water can be measured in terms of:

- Costs incurred due to quality deficiencies (N)
- Time to collect water (A)
- Payments made for water (N).

Bearing in mind that priority should be given to ensuring that people have access to basic necessities, indicators that focus on access and safety (such as supply location relative to the home) should take precedence over items that address such other qualitative aspects as type of supply. The task then becomes one of collecting statistics on such micro-indicators and of agreeing on protocols for combining them.

Indicators can only be as good as the data supporting them, yet detailed data rarely exist. Of the few existing case studies, one by Bank staff for Baku, Azerbaijan, confirms our observation that overall performance of a public water supply system cannot be accurately measured merely by considering the percentage of population with access to safe water (box 3.3).

Level II Indicators: Technical and Financial Performance

A utility can be assessed for both technical and financial performance. The utility itself, the financing agency, and the government are interested in information on the utility's financial and technical health. Such indicators, however, rarely have much to do with access or safety apart from the notion that service quality declines in financially or technically unsound utilities.

The technical performance of a water utility can be measured in terms of:

- Water consumption (number of connections, number of standpipes, unit consumption, proportion metered, distribution of water consumption) (A)
- Water quality (physical, chemical, bacteriological) (S)
- Sewerage system (number of connections, length of sewer system, infiltration rates) (N)
- Water distribution system (length of pipes, storage volumes, pipe breaks, estimates of leakage) (N)
- Personnel (number of staff per thousand connections, staff composition, and staff costs) (N).

The financial performance of a water utility can be measured by a number of indicators, including:

- Short-run debt-paying ability (N)
- Ratio between operating expenses and operating revenues (N)
- Ratio between cash collected and average annual billings (N)
- Debt-to-equity ratio (N)
- Ratio of inventory to fixed assets (N)
- Return on net fixed assets (N)
- Return-to-equity ratio (N)
- Contribution to investment (N)
- Composition of the revenue structure (N)
- Debt-service coverage ratio (N)
- Composition of operating costs (N).

The World Bank has collated information on the technical performance of utilities in about a dozen countries, four or five of which are developing.

Box 3.3. How people in Baku, Azerbaijan, get water

Although almost 100 percent of Baku's households are officially connected to the public supply system, water is available to individual families on average only twenty-two days a month, eleven hours a day. This suggests that water is available the equivalent of 121 days a year—approximately a third of the time. Clearly this is not the same access as is enjoyed by people with a continuous supply of water, and it is not necessarily better than the access for people who draw on supply types other than piped water (such as private wells). In such cases households often rely on complex mixtures of sources, each with its own access attributes.

Only 13 percent of the households in Baku believe that the water they receive is clean. Most households, moreover, have developed alternative strategies to cope with insufficient and irregular public water supply. Three-quarters boil tap water, half install storage facilities, almost a quarter drill private wells, and a fifth buy water from vendors. On average households spend about seventeen times more on alternative water supplies than on their monthly water bills. (As an added benefit, the social assessment undertaken to gather this information generated informed public participation.)

Source: Ayse Kudat, "Azerbaijan: Baku Water Supply Rehabilitation Project." Environment Department Papers, Social Assessment Series no. 17. World Bank, Washington, D.C., May 1995.

Data on the bacteriological, chemical, and physical characteristics of water are available from GEMS/Water (a UNEP/WHO initiative), which provides data on more than fifty variables, including microbial pollution, suspended solids, salinity, acidity, and nitrates.

Pathogens from fecal discharges are recognized as a worldwide problem, although with proper treatment few find their way into drinking water. The major drawback of fecal coliform measurement (expressed in number of organisms per 100 milliliters) is the sensitivity of water samples to environmental conditions, primarily heat, which makes it not uncommon to find bacterial counts varying over several orders of magnitude at a given monitoring station. (Other indicators of water pollution—such as biochemical oxygen demand—will not be discussed here, since they have more to do with the health of aquatic resources. The focus of this discussion is humans' access to safe water).

Financial information is available for twenty-two water utilities from Latin America, Africa, Europe and Central Asia, and South and East Asia. The order of importance of the financial management of large natural monopolies (like water utilities), access, and safety, however, remains unclear.

Level III Indicators: Environmental Quality

Access to safe water is an example of an indicator that may seem to have limited meaning to individual households and utilities but is important as a common reference point to determine if environmental quality is rising or falling. Level III indicators combine aspects of Levels I and II that relate to access and safety.

Yet national-level generalizations based on comprehensive but location-specific information remain problematic. To support the policymaking process in developing countries, Level I and II indicators need to be collected widely. Individual results must then be aggregated for use by decisionmakers.

One difficulty with aggregating detailed information is the existence of differences between urban and rural situations and across locations. Such aggregation problems rarely arise in assessing the financial and technical capability of utilities across a nation because these are monetary measures. But the problem of spatial difference is often encountered where aggregation is attempted (as for data on forests and on biodiversity, noted in previous chapters). Weighting the different aspects of access and safety is yet another issue to be addressed when aggregating data.

Directions for Further Work

The foregoing discussion underscores the need to shift the policy focus from trying to increase the quantity of water-supply services to ensuring the quality and reliability of existing services. These new goals fit in with the new agenda for achieving the sustainable and environmentally sensitive management of water resources.[8] Clearly the quest to provide safe and reliable water supply services to the underserved and to upgrade existing services must continue. Future work must therefore identify those aspects of access to water and safety that should take priority for measuring the impact of present interventions and monitoring progress on these fronts.

Notes

1. The concept of DALYs is discussed in World Bank, *World Development Report 1993* (New York: Oxford University Press, 1993).

2. World Bank, *World Development Report 1992* (New York: Oxford University Press, 1992).

3. Thomas Selden and Daqing Song, "Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emission?" *Journal of Environmental Economics and Management* 27 (1994):147–62.

4. Particulate generation has been estimated using the Industrial Pollution Projection System (IPPS) and the Decision Support System for Industrial Pollution Control (DSS/IPC) developed at the World Bank. World Bank, "The Decision Support System for Industrial Pollution Control," draft, 1995. See also H. Hettige, P. Martin, M. Singh, and D. Wheeler, "The Industrial Pollution Projection System." Policy Research Working Paper no. 1431. Policy Research Department, World Bank, Washington, D.C., 1995.

5. World Health Organization, *Development of Environmental Health Indicators* (Geneva: WHO, 1995).

6. World Bank, *World Development Report 1993*, p. 91.

7. World Health Organization and UNICEF, *Water Supply and Sanitation Sector Monitoring Report 1993* (New York: UNICEF, 1993).

8. See Ismail Serageldin, *Toward Sustainable Management of Water Resources* (Washington, D.C.: World Bank, 1995).

Chapter 4

Are We Using Resources Efficiently?

With the world population rising, people the world over will have to learn to satisfy expanding needs with finite natural resources. Technology has played a crucial role in providing more goods to more people and can still help us find ways to use renewable and nonrenewable natural resources more efficiently. At the same time consumption patterns and preferences can—and should—be adapted to new realities. But to achieve these ends, indicators are needed to assess progress in both production and consumption.

Different Economies Consume Resources at Varying Rates

Resource intensity can be broadly indicated by the ratio of inputs to outputs, that is, the weight or volume of raw materials to gross national product (GNP). Preliminary studies suggest that the weight of materials per unit of constant GNP at the world level has declined since 1970. Such a decline is good news, since the processing and transportation of heavier materials generally requires higher energy inputs and thus leads to greater pollution.

The trend toward lower weights-to-GNP ratios may also indicate a responsiveness of production processes to market signals. Heavier materials tend to be more expensive to process, thereby encouraging more efficient use. This logic could be extended to encourage more efficient use of materials in terms of volume if the true social cost of the disposal of waste materials—which is in part a function of landfill volume—were incorporated into production costs.

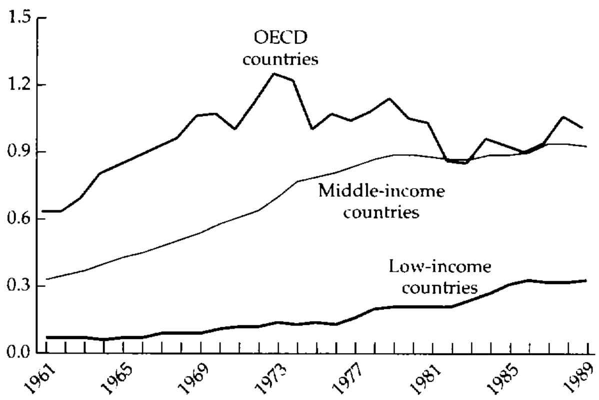
To the extent that materials can be reused or recycled, the environmental impact of material use can be mitigated. With increased consumption, however, additional impacts on the environment are likely to result. Examination of international records for the past three decades suggests that global consumption of primary aluminum, copper ore, lead ore, manganese ore, nickel ore, phosphate rock, crude steel, tin ore, and zinc ore rose by 120 percent between 1961 and 1989. More than half of this increase occurred during the 1960s (figure 4.1).

Increased consumption rates were most profound in low- and middle-income nations, where consumption between 1961 and 1989 rose 360 percent and 169 percent, respectively. The average growth rate among low-income nations peaked in the 1970s at 7 percent and fell to 5 percent in the 1980s. Among middle-income nations this growth rate was highest during the 1960s at 6 percent, falling to under 1 percent in the 1980s. OECD nations have also considerably slowed their consumption increases since 1970. On a global level, annual growth rates slowed from 6 percent in the 1960s to about 2 percent in the 1980s.

While both low- and middle-income countries increased their share of global consumption between 1961 and 1989, the most significant

Global metal and mineral use rose by 120 percent between 1961 and 1989

Figure 4.1. Consumption of metals and minerals, 1961–89
(Metric tons)
OECD 1971 = 1.0

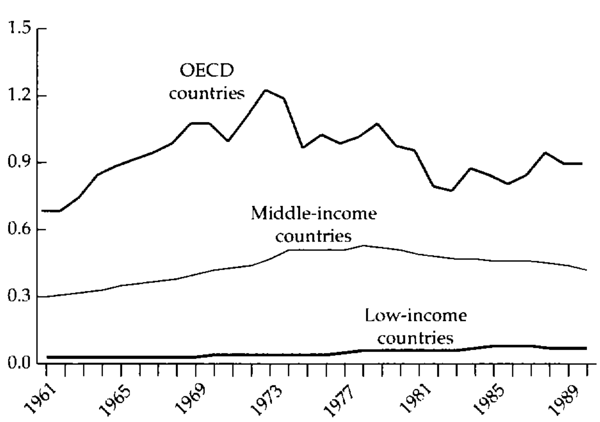


Source: See appendix.

increase occurred in low-income countries, whose share of global consumption rose from 7 to 14 percent. The share of middle-income countries rose from 31 to 38 percent. By contrast, OECD countries' consumption of metals and minerals fell from 59 to 44 percent. During this period, low-income countries' share of global population increased from 55 to 59 percent, while OECD countries' share fell from 21 to 15 percent. Thus on a per capita basis, consumption of metals and minerals in low-income countries rose by 144 percent between 1961 and 1989. Even so, per capita consumption in these countries was quite small when compared with that in middle-income and OECD countries, which experienced 39 percent and 30 percent increases over three decades (figure 4.2).

OECD countries continue to use by far the most metals and minerals

Figure 4.2. Per capita consumption of metals and minerals, 1961–90
(Metric tons)
OECD 1971 = 1.0



Source: See appendix.

Implications for the Future

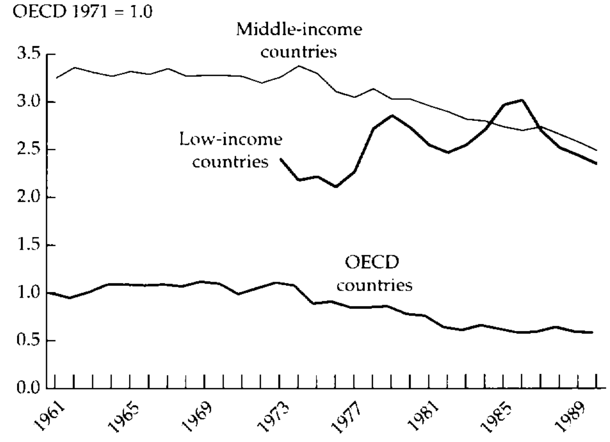
There is some evidence that metals and minerals are now being used more efficiently, particularly in middle-income and OECD countries, where consumption of raw materials per unit of constant GNP has fallen over time (figure 4.3). The largest decline occurred in OECD countries (42 percent) and middle-income countries (39 percent), followed far behind by low-income countries (2 percent). Yet the monetary value of material inputs to constant GNP has not followed the same downward trend, which could indicate a shift toward higher-valued materials or increasing value for the same materials (figure 4.4). Further study will be required to clarify these seemingly contrary predictions.

There also is evidence in support of the environmental Kuznets-type curve (figure 4.5). The consumption of metals and minerals per unit of GNP rises to about $1,700 of per capita income, then falls with further income increases.[1] As countries make the transition from low-income to lower-middle-income status, consumption of

OECD and middle-income countries have cut their minerals use per dollar of GNP by roughly two-fifths, suggesting greatly improved efficiency

Figure 4.3. Consumption of metals and minerals per unit of GNP, 1961–90
(Metric tons)

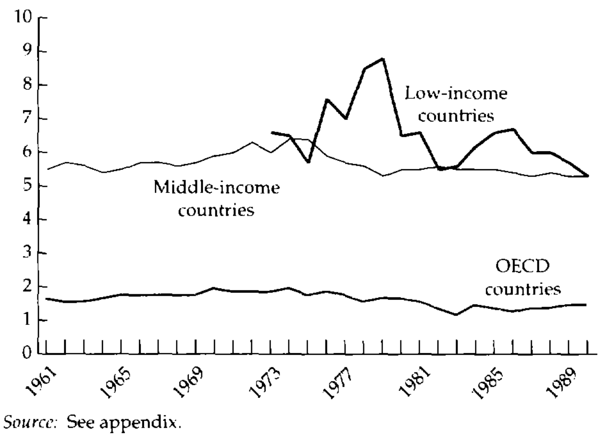
OECD 1971 = 1.0



Source: See appendix.

The flat monetary value of material inputs to GNP in OECD and middle-income countries suggests increasing input values or a shift toward higher-valued materials

Figure 4.4. Consumption of metals and minerals per unit of GNP, 1961–90
(Thousands of U.S. dollars)
OECD 1971 = 1

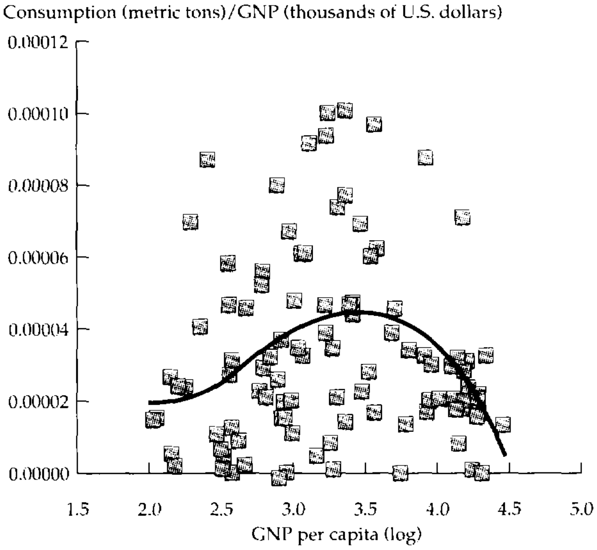


Source: See appendix.

metals and minerals per unit of GNP apparently increases as manufacturing industries claim a larger share of national income. However, among upper-middle and high-income countries, consumption of metals and minerals per unit of GNP drops considerably with the shift toward service industries and also, perhaps, because of increased efficiency in manufacturing.

Once per capita income reaches $1,700, consumption of metals and minerals declines

Figure 4.5. Kuznets-type curve for metals and minerals, averaged 1988–90
Consumption (metric tons)/GNP (thousands of U.S. dollars)



Source: See appendix.

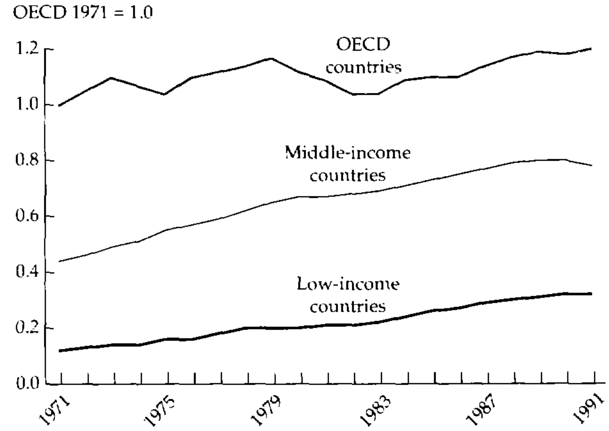
Global energy consumption in equivalent tons of oil rose by 48 percent between 1971 and 1989. The largest percentage of change occurred in low-income countries, where consumption increased by 161 percent (figure 4.6), while that in middle-income and OECD countries rose by 80 percent and 20 percent. Similarly per capita consumption increased 73 percent in low-income countries and 16 percent in middle-income countries over the past two decades. But while it increased just 5 percent in OECD countries between 1971 and 1991, per capita consumption there remains twice that of middle-income countries and more than ten times that of low-income nations.

Finally, in terms of intensity of use, energy consumption per unit of constant GNP declined by almost 19 percent on a global basis between 1971 and 1991 (figure 4.7). Low- and middle-income countries today are equally intensive in energy use, while OECD countries are significantly less intensive. (Consumption trends for fossil fuels tend to mirror those for all energy sources.)

Fears that the world may be running out of sources of energy, particularly fossil fuels, rest on expectations of rising consumption rather than on present-day resource constraints. The world's proven reserves of oil and gas today are, in fact, significantly larger than they were in the 1960s. But if low-income and middle-income countries prove to be as heavy consumers of energy as OECD countries, increases in their consumption of commercial energy could change the picture substantially. It is

Even though use has risen in poorer countries, OECD countries still consume ten times more energy

Figure 4.6. Energy consumption, 1971–91
(Metric tons of oil equivalents)
OECD 1971 = 1.0

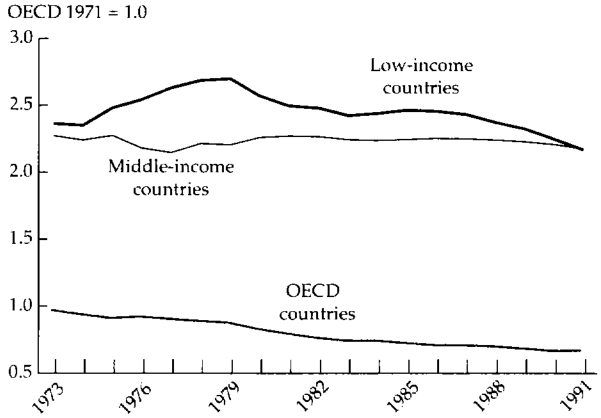


Source: World Bank.

A global decline in energy use of 19 percent indicates decreasing intensity worldwide

Figure 4.7. Energy consumption per unit of GNP, 1973–91

(Metric tons of oil equivalents per unit of GNP)



Source: World Bank.

also increasingly important to monitor the environmental impacts of energy use, since they could well trigger increased dependence on such cleaner renewable energy sources as solar and geothermal energy, hydropower, and wind.

Directions for Further Work

The question of the efficiency of resource use is, at one level, similar to any other question of economic efficiency. But resource use has particularly important ramifications for environmental quality. The stages of extracting and refining energy-producing resources to their basic functional forms (such as ingots of metal) have the greatest environmental impact. The Kuznets-type curve describes the situation in a cross-section of countries at a given time. But the real question is whether countries have to go through all of the successive stages of development. Recent analyses suggest not, since technical progress can significantly flatten the curve.

But more refined indicators of resource use relative to income generation will be needed to pursue this theory. For example, something other than GNP should be used as the denominator in calculations of energy consumption like those in figures 4.3, 4.4, 4.5, and 4.7. In principle, a "green" variant of income should be used, although there are signs that this would not appreciably alter the conclusions reached here (see chapter 7).

Of greater analytical concern are the effects of the shift toward service economies as development progresses. While a narrower measure of income might qualify the predicted effects, allowance for transportation, warehousing, and other resource-intensive services would have to be included in any calculation—something that cannot be done with the global data bases available now.

More generally, much of the analysis in this chapter can be viewed as a simplified form of input-output analysis. If formally incorporated into the UN system of national accounts, this form of analysis could help flag the most- and least-efficient processes for transforming natural resources into economic goods and services. Researchers also are extending the logic to account for such unpriced inputs as air and water and such uncosted detrimental outputs as air and water pollution.

The input-output tables that already exist for many countries are not coordinated and rarely designed in a way that helps identify underlying physical quantities of inputs and outputs as opposed to money flows. Distorted relative prices for inputs, outputs, or both, moreover, can lead to misleading assumptions when input-output tables are used in "raw" form. There are now efforts to marry data tables with underlying—but separately generated—matrices of prices and quantities to improve our understanding of the economic and environmental aspects of transformation processes at work.

Note

1. World Bank, *Atlas* (Washington, D.C.: World Bank, 1994).

Chapter 5

What Role Do Taxes and Subsidies Play?

How countries use financial resources is a critical issue in achieving environmentally sustainable development. The extent to which tax and subsidy regimes encourage the sustainable—or unsustainable—use of the environment is therefore a key policy question. Rates of taxes and subsidies on goods and services are important indicators of the incentive structures created by government policies, which either favor or work against sustainability.

Taxes Discourage, Subsidies Encourage Energy Use

Governments make wide use of taxes and subsidies as tools to influence behavior and reach policy goals. But although economists generally agree that taxes on such recognized evils as pollution emissions would be an efficient means of reaching environmental targets, few governments currently impose environmental taxes.

On the other hand various subsidies on goods and services have serious environmental ramifications. Examples include subsidies—implicit or explicit—on energy consumption, pesticide use, timber harvest, and water use. Although these subsidies are aimed at promoting such social goals as affordable energy for the poor or greater agricultural production, many have side effects that are damaging to the environment.

Subsidies for electricity and fossil fuel in 1991 are estimated to have been on the order of $106 billion worldwide (excluding countries of the former Soviet Union, which certainly had high subsidies, although these cannot presently be analyzed or expressed unambiguously in dollar terms). To put this figure in perspective, it is equal to 0.5 percent of gross world product, or twice the amount of official development assistance.

Energy subsidies work against the achievement of environmentally sustainable development at a number of levels. They divert public money from programs with higher potential social payoffs, and they increase government deficits. By artificially lowering energy prices, they reduce the incentive to use energy efficiently, resulting in excessive consumption, with its attendant effects on the emission of pollutants and greenhouse gases. Subsidies also encourage excessive investment of resources in energy-intensive enterprises, crowding out capital for other economic sectors. In nations that are energy producers, moreover, excessive domestic energy use reduces supplies available for export.

The distributional effects of energy subsidies are likely to be particularly important in developing countries. Energy subsidies can increase the access of poor households to energy. For instance, energy use in wealthy northern countries makes up a larger proportion of the budgets of poor households than of affluent ones, because energy is a basic need in colder countries. However, precisely the opposite is true in developing nations. In those nations, therefore, energy subsidies are subsidies to the relatively affluent. By exacerbating the problem of inequitable income distribution, energy subsidies undermine the social equity required for environmentally sustainable development.

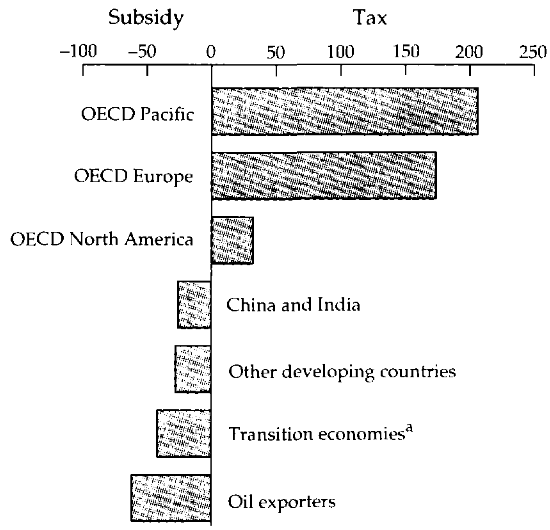
Who Taxes, Who Subsidizes?

In most industrial countries energy use is taxed to varying degrees and for a variety of reasons having to do with funding transportation infrastructure, promoting energy efficiency, and limiting traffic congestion. These taxes are typically not for environmental purposes, although they clearly have environmental benefits. The best way to put energy tax and subsidy issues in perspective, therefore, is to compare tax and subsidy rates across industrial and developing countries.

In figure 5.1 a tax or subsidy rate of 0 percent represents the sale of fossil fuels at their world producer price. Of the developing countries that subsidize these fuels, many—including China and India—subsidize them at 26 to 28 percent of the world price. Excluding countries of the former Soviet Union, economies in transition had subsidies of over 40 percent in 1991, while oil exporters had subsidies that exceeded 60 percent.

Taxes in OECD countries raise fuel prices and discourage use, while subsidies elsewhere encourage use

Figure 5.1. Fossil fuel tax and subsidy rates, 1991
(Percent)



Note: See appendix.
a. Except former Soviet Union.
Source: World Bank estimates in B. Larsen, "World Fossil Fuel Subsidies and Global Carbon Emissions in a Model with Interfuel Substitution." Policy Research Working Paper no. 1256. Policy Research Department, World Bank, Washington, D.C., 1994.

By contrast, industrial countries tax fuel use. In North America fuel tax rates are a little over 30 percent. Rates rise to over 170 percent in Europe and 200 percent in the Pacific.

Combining tax and subsidy rates offers a new perspective on the phenomenon of subsidization. China, India, and other developing countries price fossil fuels at about 75 percent of the world price, but this pricing represents 56 percent of the price charged for fuel in North America and 24 percent of the price in OECD Pacific countries.

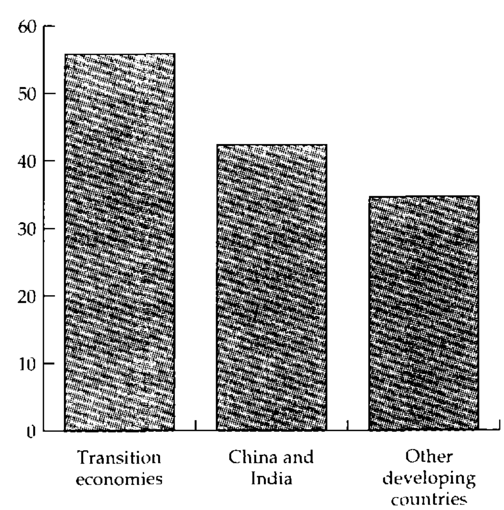
Electricity, while generally not taxed in industrial economies, is subsidized in many developing countries. Figure 5.2 shows electricity subsidy rates for developing countries with the largest total level of subsidies. Electricity subsidies in developing countries were estimated at $53 billion in the early 1990s. Among the major subsidizers of energy in 1991, the average level of total subsidy was 3.6 percent of GNP. At this level, moreover, serious misallocation of investments for development can be expected to occur.

Environmental Consequences

Energy subsidies not only distort investment decisions, they also lead to excess emission of pollutants. (Emissions that would not have been

Transition economies devote 3.6 percent of GNP to electricity subsidies

Figure 5.2. Electricity subsidy rates, 1991
(Percent)



Note: See appendix.
Source: World Bank estimates in J. Heidarian and G. Wu, "Power Sector Statistics for Developing Countries (1987–1991)," Industry and Energy Department, World Bank, Washington, D.C., 1994.

produced had energy been sold at world producer prices in the subsidizing countries are considered "excess.") Subsidies on fossil fuels alone are estimated to have caused roughly 450 million metric tons of excess carbon dioxide emissions in 1991. Excess emissions therefore represent roughly 2 percent of world emissions of carbon dioxide from fossil fuel combustion.

Without knowing policy goals, which vary from country to country, there is no sensible way to designate a "correct" level of energy taxation. Figure 5.1 gives the impression, however, that energy tax rates are extremely low in North America. If the United States taxed liquid fuels at the same rate as in Europe, and if (as is generally calculated) every 1 percent rise in fuel prices produces a 0.5 percent fall in demand, then carbon dioxide emissions would decline by over 1 billion metric tons. Using European energy taxation rates as a benchmark, therefore, excess carbon dioxide emissions in the United States represent roughly 5 percent of world emissions from fossil fuel combustion.

But the foregoing analysis indicates that, even excluding the countries of the former Soviet Union, energy subsidies—at $106 billion—were equally significant at the world level in 1991. Although disentangling the effective levels of energy subsidies in the countries of the former Soviet Union has proved extraordinarily difficult, there are some indications that their subsidies were of the same order of magnitude as those in other transition economies. The official target in the Russian Federation was to raise domestic prices for oil and natural gas to 67 percent of world levels by the fourth quarter of 1993. Rapid reform since 1991 has been reducing subsidy levels throughout East European transition countries (table 5.1), most notably in Poland.

Table 5.1. Excess carbon dioxide emissions, 1991
(Thousand metric tons)

Source	*Carbon dioxide emissions*		*Percentage reduced by eliminating subsidy*
	Total from fossil fuels	*Excess from fuel subsidies*	
China and India	3,087,638	169,010	5.50
Other developing countries	274,390	16,787	6.10
Transition economies	674,930	151,964	22.50
Oil exporters	958,158	114,305	11.90
Total	4,995,116	452,067	2.05

Source: See appendix.

Directions for Further Work

Apart from practical difficulties in cataloging explicit taxes and subsidies, producer and consumer equivalents (quantitative restrictions, licensing and permit requirements, indirect taxes and subsidies, and so on) loom large in some areas—notably agricultural and water resource management. Broader measures are needed to assess the price wedges introduced by official actions. These can be computed in some cases by extending measures of explicit taxes or subsidies for selected items (a technique refined by the U.S. Department of Agriculture for comparing prices of selected products in different producer countries). However, the only prospect for doing so systematically for any economic activity—and potentially any country—is to recast price information collected under the UN's International Comparisons Programme.

Subsidies on the use of water and pesticides, just as those on energy of fossil fuel, can drain national finances and promote inefficient use of environmental resources. As in the case of energy, these subsidies serve to increase income disparities within developing nations.

A clear dilemma exists between incentive systems to improve environmental performance or to mitigate environmental impacts and national taxation systems. The two are often out of line. Many national governments need to review the consistency between their business tax assessment laws and disallowance of environmental costs in order to improve business responsiveness.

Regarding tariffs on water and sanitation, a 1994 World Bank review indicates a significant increase in recent years. Average tariffs are now in the range of $0.90 to $1.35 per cubic meter, whereas a few years ago they were in the range of $0.30 to $0.40. While price increases alone do not inevitably indicate more efficient use of resources, such rises suggest that progress is being made in reducing subsidies by transferring costs to beneficiaries.

Developing countries subsidize the use of pesticides through a variety of methods. The techniques include preferential foreign currency exchange rates for imports, import duty exemptions, reduced sales taxes, agriculture credits, and the provision of free pesticides to farmers. Studies in the mid-1980s revealed that pesticide subsidies were widespread and substantial, with subsidy rates ranging from 19 percent to 89 percent of the market price.

From a policy perspective, eliminating or reducing subsidies on energy, water, and pesticides represents a classic "win-win" situation. The government, the economy, and society at large all benefit from the reduction of the inefficiencies and distortions produced by subsidies, and equity is increased. Major benefits to the environment can be expected as well—in the form of reduced air pollution, lower emissions of greenhouse gases, less pressure on water supplies, and reductions in the runoff of pesticides into waterways.

Given the variety of price and quantity schemes that governments use to influence the price of such key commodities as energy, the appropriate analytical framework for the derivation of indicators is clearly that of the purchasing power of currencies, based on the UN's International Comparisons Programme (ICP). Only expanding the coverage and timeliness of ICP data sets will permit analysts to disentangle the effects of various policy interventions and to reveal the implicit tax and subsidy rates applied by countries.

Data problems aside, ICP seeks to compute the average price for a basket of goods and services (GNP or GDP) based on detailed price information, supported by exercises to match products in different countries. These details include prices for such basics as gasoline, electricity, water, and foodstuffs—whose prices to consumers may (or may not) be lower because subsidies somewhere along the value chain have made input costs artificially low. For studies of environmentally sustainable development, such specific details could be compared to each other. Broader price baskets, including the standard ones produced by the ICP process, could also be tracked across reporting countries and over time to provide measures of effective tax and subsidy rates.

As a minimum, ICP-type measures can provide an analytical check on direct estimates of taxes and subsidies. For example, quick estimates suggest that the relatively modest tax on fossil fuels in North America (see figure 5.1) translates into an effective subsidy in ICP terms. But the real analytical gain with ICP-type measures is that they can be fitted easily and naturally into the kind of relative price issues that countries face when considering sectoral or structural adjustment. The flagging of relative price changes that are essential for environmentally sustainable development could thus become a more systematic approach to reconciling official price wedges in specific areas within the general move toward market prices.

CHAPTER 6

Are We Sharing the Burden of Reducing Climate Risks?

Gauging the extent to which current economic activity is affecting the welfare of future generations requires indicators for "global commons"—resources that transcend national jurisdictions but are essential for environmentally sustainable development. In addition to indicators for the state of the oceans and marine resources, indicators are also needed to measure atmospheric pollutants. One country's greenhouse gas emissions affect the climate for all nations—perhaps the classic example of a global common. To minimize the damage from greenhouse gases, moreover, requires international agreement.

Setting Stabilization Targets

The topic of greenhouse warming is a controversial one. Although the physical processes of greenhouse warming are increasingly well understood, the degree of warming arising from increases in atmospheric concentrations of carbon dioxide cannot be measured directly, and only broad ranges can be estimated through modeling. It is even possible to question whether it is more efficient to adapt to climate change rather than pay to prevent it. Despite these uncertainties, more than 150 countries signed the UN Framework Convention on Climate Change. The agreement became legally binding in March 1994, and many signatories voluntarily set a target to stabilize their carbon dioxide emissions at 1990 levels by 2000.

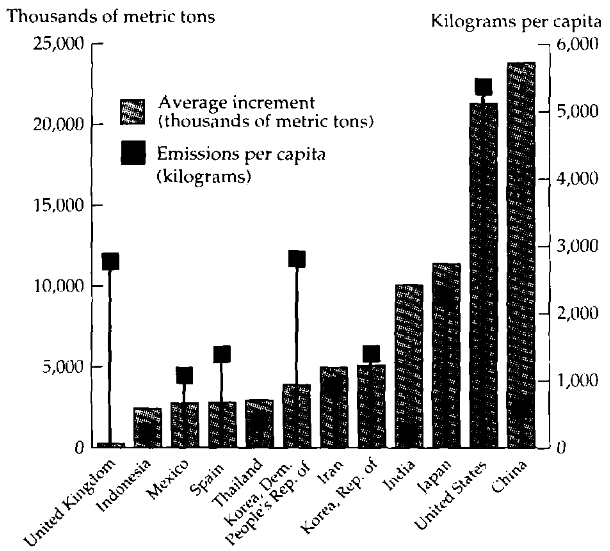
While the pledge to stabilize emissions seems to be a responsible one, we do not yet know whether continuing addition of carbon dioxide to the atmosphere at the 1990 rate is a prudent goal. Neither can the convention be seen as an agreement on the fairness of the relative contribution of each country to total world emissions of carbon dioxide in 1990.

Who Emits What

A key indicator of progress toward stabilizing emissions is the amount by which each nation's emissions increase from one year to the next—their incremental emissions. Clearly the greatest impact on climate stabilization will be for the largest incremental emitters to stabilize their emissions. But the further we go into the decade of the 1990s without stabilization, the more difficult it will be to meet the internationally accepted voluntary target.

Figure 6.1 pictures the dozen largest incremental emitters in 1986–91. As expected, wealthy countries (such as the United States and Japan) are near the top of the list. But populous poorer nations (such as China and India) are also large emitters. To put this fact in perspective, the figure also shows the corresponding total emissions from fossil fuels per capita. Although its total incremental emissions were less than those of China, the United States emitted more than twice the amount of carbon dioxide per capita as Japan, *Despite having lower incremental emissions than China, the United States emits nearly ten times the carbon dioxide per capita*

Figure 6.1. Incremental emissions from fossil fuels and emissions per capita, 1986–91 averages



Source: Carbon Dioxide Information Analysis Center; see appendix.

nearly ten times as much as China, and more than twenty times as much as India.

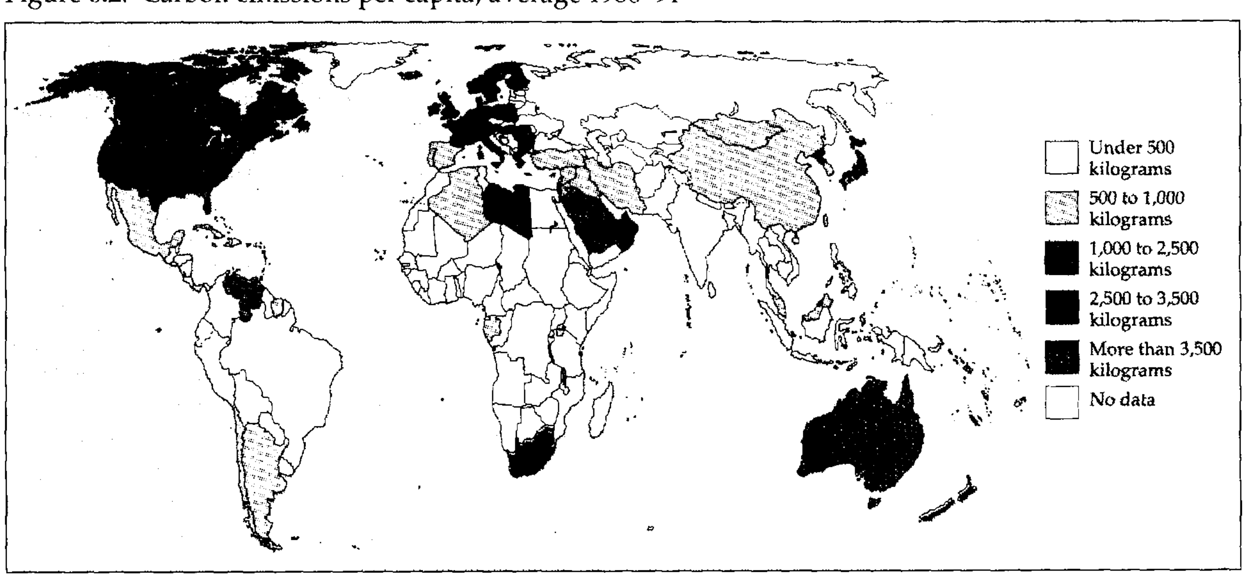
Overall on a per capita basis, the rich world is the largest emitter of carbon dioxide (figure 6.2). The largest emitters per capita include the United States, Canada, Australia, Singapore, and many of the oil-exporting countries. At the other end of the spectrum, the poorest nations in Africa, Asia, and Latin America emitted less than 500 kilograms of carbon dioxide per person per year—less than one-eighth the rate of the highest emitters.

The figure of 500 kilograms is a useful guidepost: if carbon dioxide concentrations by 2100 are to be held to less than double the concentrations recorded around 1800 (roughly the start of the Industrial Revolution), average carbon emissions per capita for the total human population during the three centuries from 1800 to 2100 cannot exceed 560 kilograms. Yet from 1986 to 1991 alone, 73 percent of carbon emissions came from countries emitting more than 560 kilograms per capita. It must also be noted that holding carbon dioxide concentrations to double their preindustrial levels is not a criterion for sustainable development but is rather viewed by many as a pragmatic goal for limiting greenhouse warming.

Categorizing countries according to average annual increments in carbon emissions from fossil-fuel burning and cement manufacture during 1986 to 1991, two basic messages emerge (figure 6.3). First, size counts. When considering annual increases, the largest incremental emitters were China, India, Indonesia, Japan, and the United States. Second, economic performance counts as

At 500 kilograms per capita, emissions in poor nations average less than one-eighth those in OECD countries

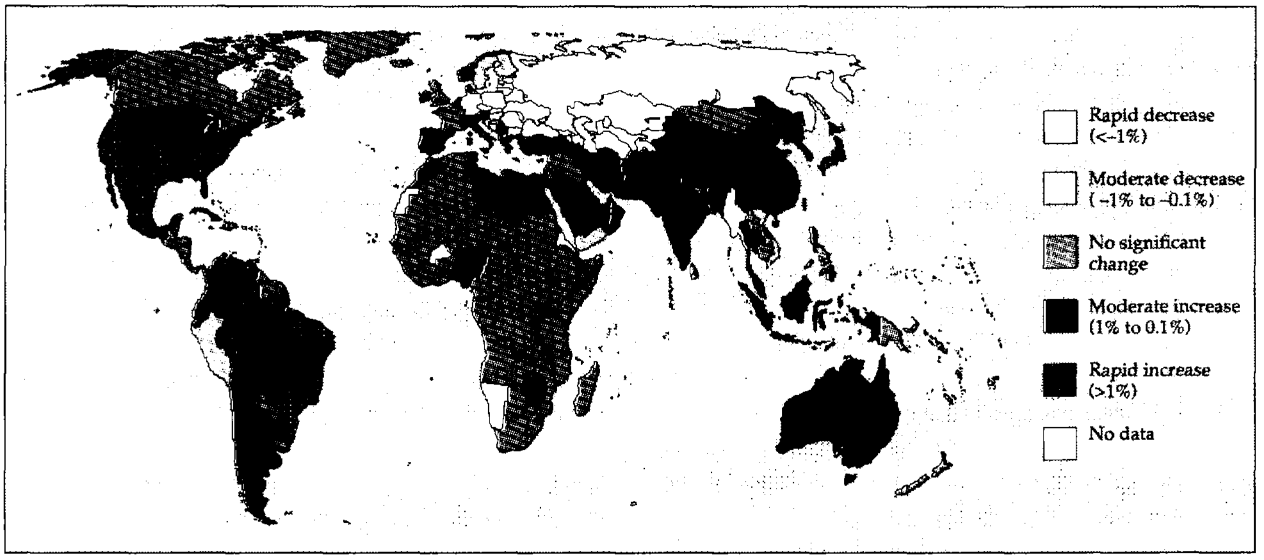
Figure 6.2. Carbon emissions per capita, average 1986–91



Source: Carbon Dioxide Information Analysis Center.

The largest incremental emitters include large economies (Japan, United States), countries with large populations (China, India), rapidly industrializing economies (Korea, Mexico, Thailand), and oil-exporting countries

Figure 6.3. Contribution to global increase in carbon emissions from fossil fuel, 1986–91



Note: See appendix.
Source: Carbon Dioxide Information Analysis Center.

well. The largest average annual decreases in emissions were registered by the former Soviet republics and Eastern Europe, whose economies declined sharply beginning in the late 1980s.

Beyond Carbon Dioxide

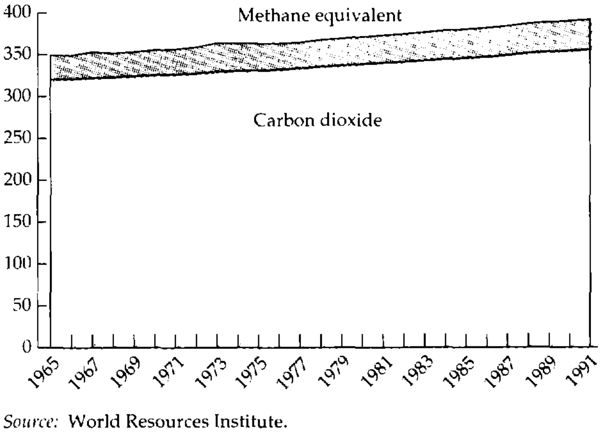
But carbon dioxide emissions from fossil fuels and cement manufacture are only part of the story. Methane is a greenhouse gas whose global-warming potential is twenty-one times that of carbon dioxide per unit of mass. Similarly, chlorofluorocarbon-11 has a global warming potential per unit mass 3,400 times, and chlorofluorocarbon-12 a potential 7,100 times, that of carbon dioxide.

Also significant in many countries is the effect of deforestation, which releases both methane and carbon dioxide. Figure 6.4 shows the cumulative atmospheric concentrations of methane and carbon dioxide since 1965, with methane measured in terms of its carbon dioxide equivalence based on its global-warming potential. Methane arises from emissions associated with livestock populations, wet rice cultivation, and the production and transport of natural gas. But while methane concentrations grew by 25 percent from 1965 to 1991 (compared with only 11 percent for carbon dioxide), the contribution to global warming represented by the methane stock in the atmosphere in 1991 amounted to only 10 percent of that of carbon dioxide.

Perhaps more significant is the methane that is presently not in the atmosphere but is held locked in ice lattices in tundra and permafrost and in shallow coastal-marine sediments.[1] Concern has been voiced that this large amount

While carbon dioxide now vastly outweighs other gases, methane—with twenty-one times the potential for global warming—bears watching

Figure 6.4. Atmospheric concentrations of the major greenhouse gases, 1965–91
(Parts per million)



Source: World Resources Institute.

of methane has the potential of being released by global warming. Although intrinsically slow, once begun this release process would reinforce itself because of methane's strong warming potential. Such a result could change the climate risk issue into a threshold phenomenon, hypothetically providing the mechanism for global warming to reach levels dramatically higher than have been assumed thus far. It also is an example of how the combination of high risk, irreversibility, and high uncertainty contributes to the controversial nature of climate change issues.

Factors Influencing Greenhouse Warming

Table 6.1 presents the average annual growth rate for carbon and non–fossil fuel greenhouse gas emissions for the top twelve incremental emitters. But these top dozen incremental emitters also accounted for more than 48 percent of the total carbon dioxide equivalent emissions in 1991. Within this group, the share of non–fossil fuel greenhouse gases in total carbon dioxide equivalent emissions varied considerably, ranging from 71 percent for Indonesia and 62 percent for Thailand to 6 percent for the Democratic People's Republic of Korea, 16 percent for China, and 15 percent for the United States.

To arrive at a more complete characterization of greenhouse gas emissions, therefore, it is important to examine these emissions relative to gross national product (GNP). Member countries of the Organization for Economic Cooperation and Development (OECD) exhibited a decline in emissions from fossil fuel combustion (per constant dollar of GNP) of 39 percent over a thirty-year span, whereas emissions from low-income countries increased by 3 percent from a base that was 2.7 times the OECD average in 1973 (figure 6.5). Middle-income nations emitted carbon at 2.7 times the OECD average in 1961, but by 1991 this figure had declined by 18 percent.

These trends reflect many factors, including efficiency of energy use and economic structure (that is, the mix of primary, manufacturing, and service business activity). For example, whereas middle-income countries are highly industrialized, OECD countries are by now mostly service-based economies. Figure 6.6 offers evidence of the tendency for middle-income countries to exhibit the maximum emissions per dollar of GNP.

Population size, income per capita, efficiency of energy use, and economic structure clearly influence carbon emissions. Thus, for example, the United States emits seven times the total carbon of India, but its incremental emission rate is only twice that of India (table 6.2). By the same token the United States emits twenty-four times the carbon per capita as does India but emits less than one-third as much per dollar of GNP.

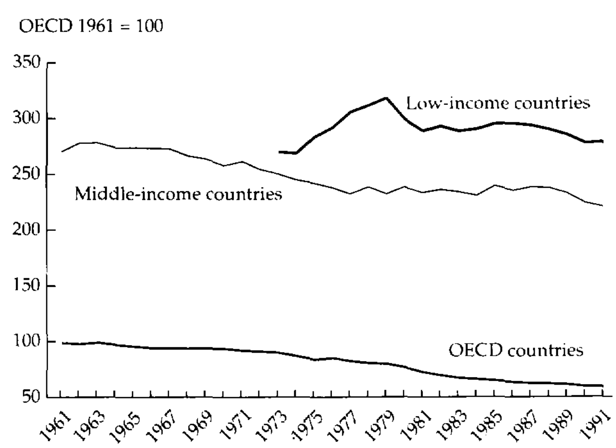
Table 6.1. Largest incremental emitters of carbon dioxide, 1986–91
(Percent)

Country	Share of total carbon dioxide emissions (1991): From non–fossil fuel sources	Share of total carbon dioxide emissions (1991): From all sources	Growth rate, fossil fuels (1986–91)
Thailand	62.4	0.9	14.6
Iran	11.9	0.8	10.3
Korea, Rep. of	11.3	1.0	8.7
Korea, Dem. People's Rep. of	5.5	0.9	6.6
Indonesia	70.7	2.0	6.3
India	37.4	3.8	6.0
Spain	26.9	1.0	5.3
Japan	27.3	5.0	4.2
China	16.1	10.2	3.7
Mexico	22.0	1.5	3.3
Italy	22.0	1.7	2.9
United States	14.8	19.5	1.6

Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, *Trends '93: A Compendium of Data on Global Change* (Oak Ridge, Tenn.: CDIAC, September 1994); see appendix.

Reflecting greater efficiency and changing economic structures, emissions in richer nations fall as GNP rises

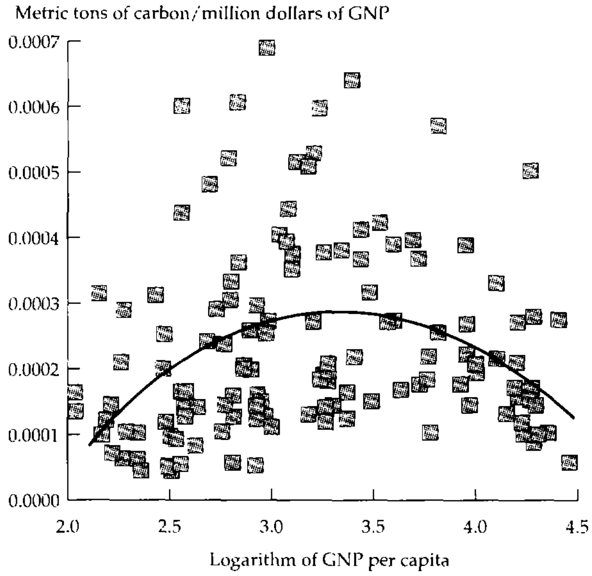
Figure 6.5. Carbon dioxide emissions from fossil fuels per constant 1987 dollar of GNP, 1961–91



Source: World Bank and Carbon Dioxide Information and Analysis Center; see appendix.

Middle-income countries emit the most carbon per dollar of GNP

Figure 6.6. Kuznets-type curve for carbon emissions, 1989–91 average



Source: World Bank and Carbon Dioxide Information and Analysis Center; see appendix.

To put greenhouse gas emissions in an economic context, recent estimates of the social costs of greenhouse warming place the damage at about $20 per metric ton of carbon emitted. These costs include the global damage to agriculture and forestry, as well as the effects of rising sea levels on coastal cities and agricultural regions. For the United States, therefore, carbon emissions from fossil fuels, which totaled 1.35 billion metric tons in 1991, will have inflicted global damages on the order of $27 billion. Adopting a global extension of the "polluter pays" principle, this means that the green GNP of the United States is about 0.5 percent lower than the traditional GNP when carbon dioxide emissions are taken into account (see chapter 7).

Directions for Further Work

As can be seen, we are a long way from stabilizing global emissions of greenhouse gases. If the voluntary target of stabilization at 1990 levels becomes a binding agreement under the UN Framework Convention on Climate Change, a number of difficult issues concerning the sharing of the burden must be resolved. The countries that showed a decline in incremental emissions from 1986 to 1991 (mostly from the former Communist bloc) will resume economic growth, but as their economic restructuring proceeds they should also be able to consume energy more efficiently than in the past. Developing countries quite naturally believe that their growth should not be impeded by emission restrictions and that industrial countries already have too much of the global "carbon quota."

One encouraging approach is the OECD GREEN model,[2] which suggests using globally tradable emission permits to achieve stabilization efficiently and equitably. Such a model would work on the principle that emitters in the industrialized world could buy emission rights from developing countries, where the marginal cost of reducing emissions is much lower. It is a large step, however, from constructing such models to operationalizing an international carbon emission trading scheme and ensuring compliance.

Table 6.2. Carbon dioxide emissions in India and the United States, 1991

Country	Emissions[a] Total	Emissions[a] Incremental	Emissions per unit of GNP[b]	Emissions per capita[c]
United States	1,346	21.3	238.8	5,320.0
India	192	10.1	784.2	221.5

a. Million metric tons of carbon.
b. Metric tons of carbon per million dollars of GNP.
c. Metric tons of carbon per 1,000 population.
Source: Carbon Dioxide Information Analysis Center and World Bank; see appendix.

Notes

1. Ice lattice structures with methane locked into them, known as clathrates, are estimated to contain some 12,000 billion tons of trapped carbon. Just 750 billion tons of carbon dioxide are present in the global atmosphere today. Clathrate carbon also exceeds the world's supply of coal.

2. J. M. Burniaux, J. P. Martin, G. Nicoletti, and J. Oliveriera-Martins, "GREEN—A Multisector, Multiregion Dynamic General Equilibrium Model for Quantifying the Costs of Curbing Co_2 Emissions: A Technical Manual." OECD Economics Department Working Paper no. 116. Paris, 1992.

Chapter 7

Are We Saving Enough for the Future?

Many actions designed to promote equity and efficiency have as a desirable by-product the accumulation of wealth. The key for translating such efforts into added wealth is saving. Economists stress the importance of saving and investment for achieving growth. Environmentalists view the same process as conservation. Similarly, sociocultural efforts to build capacity and increase local participation in decisionmaking ultimately provide individuals with the means and will to prepare for the future. In short, attention to saving may be the meeting-ground for all disciplines that must work together to make development environmentally sustainable.

Natural Resources as Assets

Deciding how much to save and in what form is no easy matter—for individuals or nations. Folklore is rich with just as many warnings against miserliness as warnings against living for the moment. Setting and achieving savings targets is particularly difficult for countries with rich resource endowments—in part because the standard national accounts measurement of saving overstates the true level of savings.

Given the limited domestic saving potential of developing countries, one means of closing the saving-investment gap is foreign borrowing. Yet in many cases, this borrowing is paid back through the export of natural capital. Natural capital can also be sold to pay for the acquisition of produced assets directly.

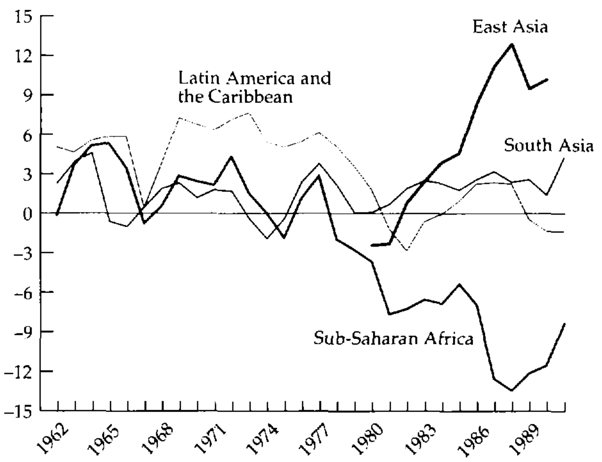
In this sense sales of natural resources can be likened to net foreign borrowing, with an imputed obligation to a national trust that owns the resources. Such imputed obligations are used elsewhere in national accounts, which record the activities of actual economic agents that perform distinct functions, such as households that operate businesses. In this case an imputed obligation would help separate the decision to sell natural capital—which means that other assets are obtained, such as foreign currency when natural capital is sold abroad—from decisions about the use of the proceeds.

Genuine Saving

Countries that are concerned with environmentally sustainable development, however defined, must pay attention to the creation and maintenance of wealth. The first step in any effort to create new wealth is to generate genuine saving—that is, the residual of production less consumption, depreciation of produced assets, and drawing down of natural resources.[1] Studies of sustainable development should also consider the human resource savings realized through investment in education and health (although this was not possible in the present preliminary exercise). As should be evident from this definition, where genuine saving is negative, it is a clear indicator of unsustainability.

In the late 1980s negative saving in Sub-Saharan Africa reached nearly 13 percent of GNP

Figure 7.1. Genuine saving as a share of GNP, by region, 1962–91
(Percent)



Source: World Bank.

Calculations of genuine saving begin with standard national accounting aggregates concerning national product, domestic consumption, and depreciation of produced assets. Use of natural resources (or "sales of assets," as this is termed below) is 50 percent of the market price for the raw material once extracted or harvested. Preliminary refinements by World Bank staff suggest that the above estimate of resource rent (the value of the resource to its owner) is low for oil production, high for some minerals, and about right for tropical timber. Carbon dioxide emissions are assigned a value of $20 per metric ton of carbon, a well-known estimate (also used in chapter 6).[2] (Carbon dioxide emissions are used as a proxy for all pollution damage caused by fossil fuel use.)

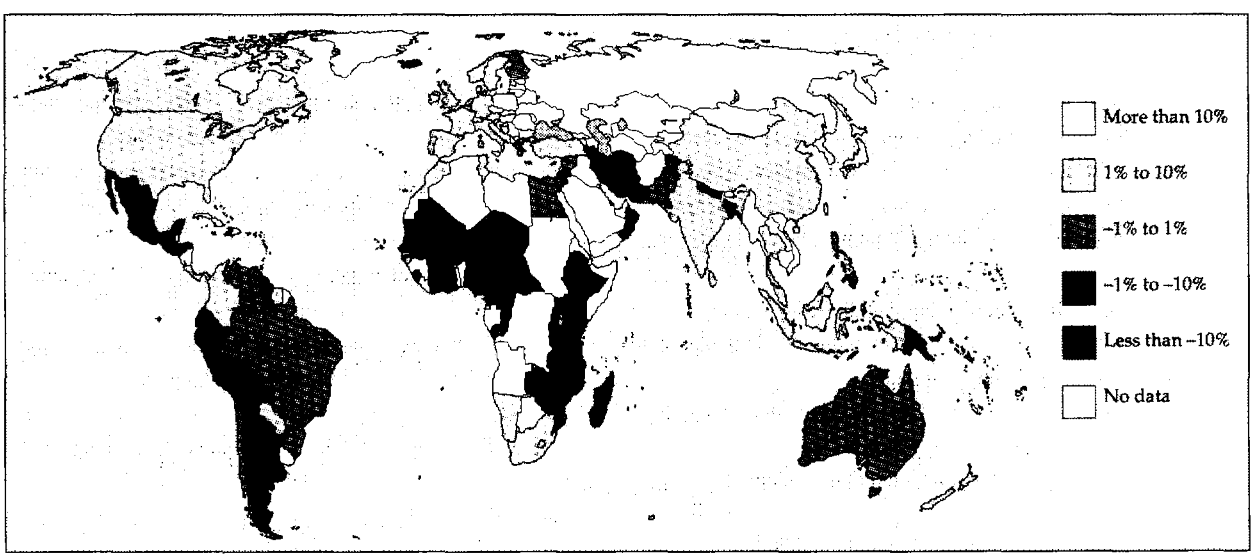
Tracking Saving Worldwide

When plotting genuine saving as a share of GNP for developing regions of the world, the most striking curve is that for Sub-Saharan Africa (figure 7.1). In that region genuine saving never exceeded 5 percent of gross national product (GNP) through the 1960s and early 1970s and turned sharply negative thereafter. A plausible surmise is that those countries never recovered from the oil shock and its reverberations. By the late 1980s dissaving in Sub-Saharan Africa had reached nearly 13 percent of GNP. This curve correlates well with the subcontinent's steady decline in living standards, as reflected in standard economic indicators.

The curve for the Middle East and North Africa region shows that saving rates have declined from their mid-1970s high. Rates for Latin America and the Caribbean have also been

Contrary to what is shown by the conventional measures of savings, many countries in fact have negligible or negative genuine saving

Figure 7.2. Genuine saving as a share of GNP, average 1989–91



Source: World Bank.

Adjusting per capita income for the sales of natural assets provides a limited explanation for trends over time (7.3a, 7.3b). More instructive is the analysis that separates asset exchanges (between produced and natural capital) from the creation of new wealth (7.3c, 7.3d)

Figure 7.3a. Per capita income variants in Latin America and the Caribbean relative to OECD countries, 1961–91

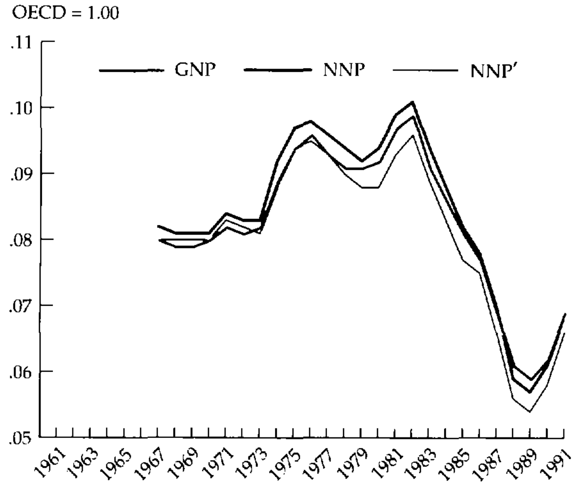


Figure 7.3b. Per capita income variants in nonfuel primary exporters relative to OECD countries, 1961–91

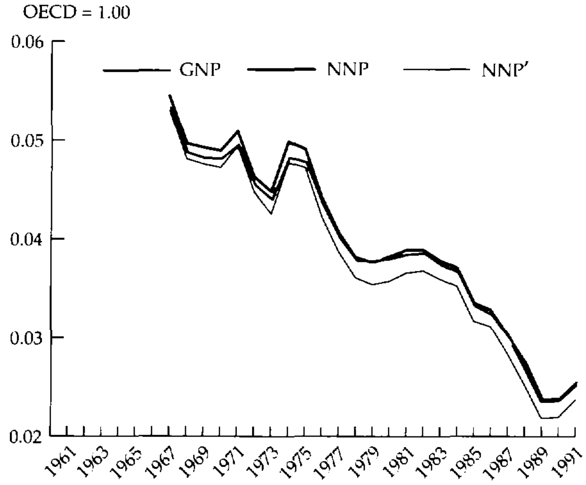


Figure 7.3c. Overall investment and savings in Latin America, 1961–91
(Percentage of GNP)

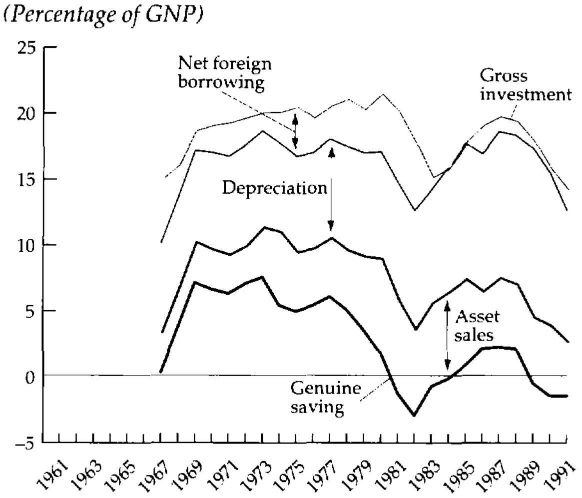
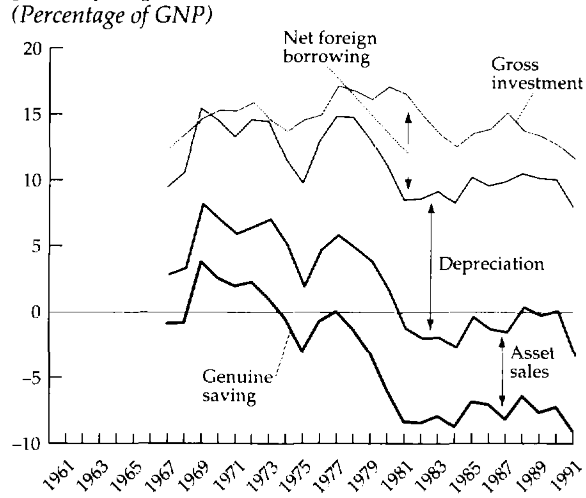


Figure 7.3d. Investment and savings of nonfuel primary exporters, 1961–91
(Percentage of GNP)



Note: Gross domestic saving = (gross domestic investment) – (net foreign borrowing). Net domestic saving = (gross domestic saving) – (depreciation of produced assets). Genuine saving = (net domestic saving) – (value of asset sales + damage from carbon dioxide emissions). See appendix.
Source: World Bank.

low and erratic, going negative at the onset of the debt crisis. By contrast, rates for South Asia were positive and steady—although small (less than 5 percent)—throughout the 1980s. In East Asia saving rates increased to nearly 15 percent in the 1980s, paralleling the phenomenal economic growth of the region's "tigers."

Average genuine saving rates from 1989 to 1991 show clearly the significantly negative savings of Sub-Saharan Africa (see figure 7.2). The countries with solidly positive saving rates (greater than 10 percent) are a mixed bunch, consisting of newly industrializing countries (such as Hong Kong, the Republic of Korea, and Singapore), industrial countries (such as Japan and Switzerland), and several East European countries (including Bulgaria, the Czech and Slovak Republics, and Poland). The high saving rates in the economies in transition may well reflect the low availability of consumer goods in the early stages of economic transformation. Most industrial countries exhibited genuine saving rates in the range of 1 to 10 percent.

To round out the picture, figure 7.3a shows trends in per capita income in Latin America and the Caribbean relative to the OECD countries, while figure 7.3b displays the same curves for one economic category, nonfuel primary exporters. In both cases per capita income has declined relative to the OECD countries, whether income is measured as gross national product (GNP), net national product (NNP), or net national product adjusted to reflect depletion of natural resources and global damage from carbon emissions (NNP′).

Figures 7.3c and 7.3d show the components of domestic saving and investment based on standard accounting identities for gross, net, and genuine saving.

For Latin America and the Caribbean, sales of resource assets peaked at roughly the same time as net foreign borrowing. Then the onset of the debt crisis caused a decrease in foreign borrowing, and genuine saving essentially disappeared. For the nonfuel primary exporters, one of the most striking features is their precipitate decline in per capita income relative to that in OECD countries. Not coincidentally the rate of genuine saving in the nonfuel exporters has been distinctly negative since the mid-1970s. In each case, gross investment looks fairly robust over the decades, which makes the declines in relative per capita income seem surprising—until one considers the signal from genuine saving.

Adjusting per capita income to reflect sales of assets clearly makes only a limited contribution to understanding economic trends over time. Since the gap between GNP, NNP, and NNP′ is narrow, choosing one variant over the other may not in itself explain why per capita income moves up or down.

Separating out the different sources of investment finance, by contrast, is analytically meaningful in a dynamic context. Distinguishing asset exchanges (sale of assets) from the creation of new wealth (genuine saving) can explain changes in income variants over time. In terms of the impact on relative positions, there are only five or six countries where a move from GNP to NNP′ matters. By contrast, adjustments to gross domestic savings, which yield genuine saving, affect the relative positions of a much greater number of countries.

The simplest prescription for environmentally sustainable development is to maintain capital intact. Yet it is clear that policies in many countries have not encouraged sustainability. What sorts of policies would help? First, government royalty regimes should be designed to capture resource rents without unduly penalizing extractors and harvesters. Tenurial arrangements for resource exploiters should encourage efficient production over time. To ensure that wealth is maintained, resource rents should be reinvested in either produced assets or human resources. Finally, the full array of monetary and fiscal policy needs to be examined in order to reduce excessive public consumption and encourage private saving.

Directions for Further Work

The crude estimates of genuine saving provided here fit the definition of optimally inaccurate indicators. They are just accurate enough to suggest that a policy issue is at stake—whether government policies are providing for the future. The most important next step in the analysis of savings behavior will be to incorporate estimates of saving through education and health investments and estimate production costs for primary materials in arriving at resource rents. These estimates would sharpen the calculation of resource rents and therefore of rates of genuine saving.

Notes

1. Basic references on genuine saving are D. W. Pearce and G. Atkinson, "Capital Theory and the Measurement of Sustainable Development: An Indicator of Weak Sustainability," *Ecological Economics* 8 (1993): 103–108; and K. Hamilton, "Green Adjustments to GDP," *Resources Policy* 20 (1994): 155–68.

2. See Samuel Fankhauser, "The Social Costs of Greenhouse Gas Emissions: An Expected Value Approach," *The Energy Journal* 15 (1994): 157–84.

CHAPTER 8

Where Is the Wealth of Nations?

Most definitions of sustainability imply that per capita wealth, broadly defined, should not decline. Surprisingly, no measures of wealth exist—despite the fact that much of economics, in theory and historically, is about the formation and distribution of wealth. Although there are daunting data problems in gauging the wealth of nations, exploratory work by World Bank staff suggests that the effort is essential to development studies.

Natural capital, even when limited to items usually given commercial value, seems to be a larger asset component than produced (human-made) assets in about half the 192 countries for which crude first estimates of wealth were attempted. In two-thirds of the countries where natural capital is larger than produced assets, it is also larger than human capital.

As a rule, however, human resources account for a larger share of wealth than do produced assets. Although measurement is even more problematic in this area, calculations (explained below) suggest that this is so for 174 of the 192 countries considered. In more than half of these nations, human resources were larger than the other two components of wealth (produced assets and natural capital) combined. Such results are broadly in line with the long-standing rule of thumb that remuneration of labor accounts for between two-thirds and three-quarters of per capita income. Yet certain interesting international patterns also emerge.

Because first estimates for individual countries are likely to change markedly as better sources and methods are developed, country-level estimates are not given here. Differences among country groups, which are more likely to be robust, are reported. The key message is also likely to hold: traditional economics gives disproportionate attention to finance and produced assets at the expense of natural capital and human resources. The findings suggest that the balance-sheet aspects of the UN system of national accounts cannot be treated with benign neglect and must share the spotlight with better-known data on flows of production, income, and expenditure data.

Why Measuring Wealth Matters

Measuring wealth, or the stock of capital, would help us to set aside the simplistic notion that sustainability requires leaving to the next generation the same amount and composition of natural capital that we found. Substituting for this notion would be the promising concept that the stock of capital that we leave future generations, defined to include all forms of capital, should be the same if not larger than what we found.

This new paradigm immediately opens the door for substituting one form of capital for another. Arguably it is most worthwhile to reduce some natural capital, such as the amount of oil in the ground, to invest in increasing human resources, for example, by educating girls. In the language of development economists, the question then becomes the degree to which we can:

- Measure each kind of capital
- Define the production function in terms of substitutability and complementarity among different kinds of capital in a dynamic context
- Define (in the absence of a common numeraire) "exchange rates" among different kinds of capital
- Define sustainability in the context of thresholds designed to select out the more efficient (highest-return) activities so that individual investments and entire strategies can be meaningfully evaluated.[1]

Such an approach may ultimately be comprehensive and rigorous, but it is a long way off. The first step toward achieving it is to measure each kind of capital.

Deciding What to Measure

Pragmatism must be our abiding concern in both the development of new measurements and methodologies and in the pursuit of policies and investments. Operationally this translates into encouraging the growth of natural capital by reducing current levels of exploitation, investing in projects such as tree plantations to relieve pressure on natural capital stocks by expanding cultivated natural capital, and increasing investment in human resources—particularly the poor, who are often both the victims and agents of economic degradation.

Recent revisions have broadened the scope of the balance sheet of the UN system of national accounts to put natural capital on a more even footing with produced assets. New growth theories and total factor-productivity studies are reconsidering the trade-offs between investing in human resources and in produced assets. For sustainable development studies, the empirical evidence gained from both exercises is important. An ambitious (but perhaps attainable) near-term goal is therefore to measure wealth in produced assets, natural capital, and human resources.

The wealth estimates are little more than a complex chain of educated guesses pointing the way for further research and more refined data work. Yet even in this crude form they provide insights into the grey area where economic, sociocultural, and ecological interests converge. They also serve as first approximations to be discarded once sounder calculations have been made. Technical experts are less likely to be shy about less-than-perfect figures when they see that even such crude efforts as this can shed useful light on key policy issues.

Balance-sheet components and movements should be seen as essential tools of analysis for achieving sustainable development. For reasons detailed elsewhere, the "greening" of per capita income alone may have little effect on the signal sent to policymakers.[2] Wealth estimates—and ultimately measures of net worth—incorporate income and outgo transactions but also reflect changes due to relative price shifts, discoveries, obsolescence, and so on. Where these adjustments are minor and random, balance sheets will tell essentially the same story as the more familiar flow data on consumption, investment, and so on. But the Bank's preliminary calculations suggest that a different story—in many ways a clearer one—emerges with a balance-sheet approach.

National and international accounting standard-setting bodies have been making progress in looking at contingent liability and disclosure requirements for environmental impacts in annual financial statements. Similarly, the UNCTAD-sponsored Intergovernmental Group of Experts on Standards of Accounting and Reporting (the ISAR Group) has researched environmental accounting and reporting issues at the business level at each of its last three annual meetings. In 1994 the ISAR Group carried out a major review of environmental disclosures in half of *Fortune* 500 global companies.[3] Many were found to be inadequate, but there was nonetheless an increased awareness on the part of companies of the need to protect the environment and of the fact that their environmental impacts were of legitimate concern to shareholders.

The short-cut methods used by Bank staff to measure the main elements of each category of wealth (produced assets, natural capital, and human resources) for essentially all countries could be recalibrated, in due course, using detailed country studies. While analysis at the country level is better left until broader valuation protocols have been discussed, the proposed estimation procedures were performed at the country level and could be used to generate annual time series for most countries.

Produced Assets

Most economic analyses focus on this category in terms of its flow, that is, gross fixed capital formation. Produced assets include machinery and transport equipment and building and construction. Surprisingly few economic studies give equal attention to the depreciation of these assets—which may help to explain why some economists see little point in considering degradation or depletion of natural capital. In contrast, depreciation allowances are an integral aspect of business accounting.

Studies looking at the stock of produced assets usually do so by using a perpetual inventory model to derive crude estimates of the stock from reported flows of capital formation and depreciation. Perpetual inventory models are inherently weak in terms of revaluation and are therefore imperfect guides to the stock-flow relationships that puzzle students of technological change. They are, however, better for that purpose than transactions data alone, as was made evident in the recent Bank study of total factor productivity that provides the basic set of estimates used here.[4]

As a means of accumulating wealth, produced assets have rather clear income-earning potential. However, given the present pace of innovation, they may also be characterized as obsolescing from the moment they begin to earn income—meaning that such potential should be at least partially offset by negative revaluation accounts when national balance sheets are compiled.

Natural Capital

Pioneering efforts to integrate environmental and economic accounting have made estimates of balances, as well as flows, of natural capital and of produced and financial assets.[5] They show that such monetary estimates can be compiled even in developing countries and can help decisionmakers see that a nation's natural endowment is as much an asset as are its machines, buildings, and bank accounts. More such detailed studies are needed, but they are costly and time-consuming. As suggested in chapter 7, short-cut methods can give crude but analytically useful estimates of "green" income and saving at negligible cost for essentially all countries. The same is true for estimates of natural capital.

Natural capital is the least-quantified factor of production, in part due to the difficulties of assigning value to important elements that are unpriced, priceless, or both. There is no technical solution to this problem. Some difficult cases—notably biodiversity—may be dealt with in a nonmonetary measure of the type explored by the World Resources Institute with support from the Global Environment Facility (see chapter 2). Including such an indicator in total factor productivity studies would be a way to begin exploring the role of natural capital in economic activity.

The present exercise focuses on stock measures for the flow items used to "green" estimates of per capita income (see chapter 7), which are essentially the raw materials important in international trade. It also puts a value on land itself since land is usually a major component of natural capital, although not directly marketable internationally as are its products (crops, subsoil minerals, and so on). Crude estimates of quantities of standing timber and subsoil assets (including water, which is not covered in flow estimates) were made and then priced (with reserve prices for water) at half the prevailing world market price for these assets, in keeping with the treatment of flow measures.

But different short-cut methods are required for valuing land. Such land prices as are reported reflect not only differences inherent in land and nations but also such locational issues as proximity to markets and infrastructure. However, prices for an equivalent "quality" of land tend to correlate with income, and the most important quality differences, abstracted from locational issues, tend to be associated with land use—where reports produced by the Food and Agriculture Organization (FAO) can provide a crude first approximation.

The present study values land as a multiple of per capita income (NNP') per hectare of equivalent land. Each nation's land was divided (based on FAO reports) among cropland (arbitrarily set at two times per capita income per hectare), forests (1.25 times income), grasslands (0.75 times income), and other uses (worth 0.25 times income, with hyperarid regions and frigid tundra being given no value as land). Using other sources, a premium of 0.5 times per capita income was attached to land with no apparent soil or water constraints and to protected areas. These adjustments were made mainly to suggest how the basic valuation method could be refined without a major new exercise to monitor land use—although such an exercise may be needed before long.

Natural resources are not usually thought of as a means of accumulating wealth, since nations essentially have whatever endowments they have. However, technology has reached the point where it makes sense to talk of "growing" soil as well as trees on plantations. Even if natural resources tend to have relatively low potential for earning income (particularly when sales of existing natural capital and the "gift" of solar energy are set aside), over the long haul most will tend to appreciate so long as the pressures of expanding human population continue and poorer countries develop. When judging the importance of natural capital to rising net worth, an intelligent manager of a nation's portfolio will look beyond modest income earnings to the prospective appreciation of revaluation accounts.

Human Resources

During the last three decades considerable progress has been made in recognizing the importance of human capital formation. Investment in people is now seen to be a very high-return investment, especially in developing societies.

Most measures of human resources are expressed on a per capita basis, which is quite different from the case of produced assets. As Theodore Schultz observed in the pioneering days of research in this field, "the most critical attribute of human capital arises from the fact that the person and his human capital are inseparable." According to Schultz, human capital "encompasses all the many attributes of a people—physical, biological, psychological, and cultural—that account for both the social values that determine preferences and the economic value of the producer and consumer services that a people render."[6]

Studies to date have focused largely on acquired skill—specifically on education narrowly or broadly defined. Education can be quantified. The recent Bank study of factor productivity, for example, measures educational attainment.[7] The measure used was compiled by cumulating the years of schooling acquired by humans alive at any given time. It was thus similar to the perpetual inventory model used for produced assets, except that the numeraire is years of schooling rather than money. For estimates of national wealth, some "exchange rate" has to be devised to translate such other numeraires into monetary terms.

Before attempting to monetize human resources, however, it should be noted that their contribution to the wealth of nations is not only more than educational attainment alone but more than educational attainment plus innate ability. Any measure of human resources should reflect the possibilities people have to take advantage of their productive capacity, which is inherently constrained in developing economies. Equating human resources with educational attainment would, in the present context, be like calculating an exchange rate based only on merchandise trade and ignoring services and capital movements. What is needed here, therefore, is a broader measure.

The compromise method developed for this study attempts first to gauge the future income pool that today's population might expect, other things being equal, discounted at 4 percent a year (an arbitrary figure, but one used also in several other studies). A "green" measure of per capita income (NNP′, described in chapter 7) is used to measure income. For the present study, human resources were valued as the residual of the (discounted) future income stream for today's population after deducting estimates for produced assets and natural capital.

The monetary estimates developed here rest on a concept of the future income stream which assumes that current per capita income and life expectancy are sustainable and that variations in the age distribution of the population will persist. Such assumptions are obviously debatable, particularly at the country level. Estimates of educational attainment rest on other debatable assumptions. For example, they disregard institutional and other considerations that prevent people from realizing their innate abilities and ignore the "revaluation" effect of acquiring skills that prove more or less valuable in a world of imperfect knowledge. Juxtaposing the two types of human resource estimates is probably better than using either alone, although to reach an overall measure of wealth, the monetary estimates used here are based solely on the residual future income approach.

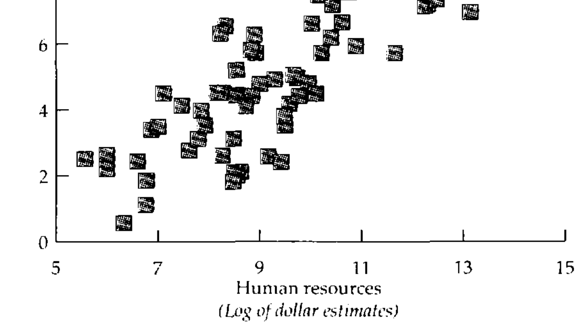
Comparing the two methods (figure 8.1) can give insight into the importance of factors other than education that affect the remuneration of human resources. Where both have been computed, there is a reasonably strong correlation ($R^2 = 0.74$) between per capita educational attainment and future income (in log form). Interestingly, educational attainment correlates equally with total wealth and with the human resources residual, and both of these score much better than either GNP or NNP′ per capita (with $R^2 = 0.5$).

Yet differences in some cases are quite large. For example, Ireland's educational attainment is the highest of the countries surveyed, and the United States ranks second. Yet the monetary measure is far higher for the United States than for Ireland.

Land quality has been (crudely) reflected in estimates of natural capital. In much the same way, estimates of educational attainment will need to be refined with qualitative factors (higher level schooling, job experience, and so on) before

Educational attainment explains many—but not all—differences in per capita wealth represented by human resources

Figure 8.1. Measuring human resources



Source: Vikram Nehru, Eric Swanson, and Ashutosh Dubey, "A New Database on Human Capital Stock: Sources, Methodology, and Results." Policy Research Working Paper no. 1124, World Bank, International Economics Department, Washington, D.C., April 1993; World Bank data.

one can judge the extent to which structural differences in economies also lead to differences in the value of human capital. Recent studies suggest that input-based estimates (educational attainment being a simple version) can differ by an order of magnitude from output, or lifetime income-based estimates.[8] While the latter are conceptually superior, they are too data-intensive for all but the most advanced countries. The human resource estimates suggested here are a low-cost approach to output-based indicators.

For purposes of wealth accumulation, human resources tend to be income-earning (after a certain age). Since people learn, they are also likely to rise in value through their lives, meaning that they have positive revaluation accounts. Brute labor is more like produced assets in the sense that it earns income but is obsolescing. Researchers are more like natural capital in that they generate little income yet are likely to appreciate over time as they produce innovations. But human resources in general are uniquely likely to have both income-earning capacity and good changes of positive revaluation accounts. This may well prove to be an important part of the explanation for why human resources can be the best possible investment even where they account for a major proportion of wealth.

What First Estimates Show

Human resourcefulness—our capacity to work for our own well-being—is our most important form of wealth. Even without considering the earth's life-support functions, natural resources are also more important to total wealth than produced assets or finance, despite the attention these are given in conventional economics.

According to preliminary estimates by World Bank staff, produced assets account for barely 16 percent of global wealth. At 20 percent, natural resources are higher, but human capital is the mainstay. Their relative scarcity globally helps to explain why the Bank is concerned with produced assets and their financing. But now that natural resources are becoming almost equally scarce, nations, the Bank, and others need to be equally concerned with this form of wealth.

Nations differ in their endowments of resources for development, or what is here called "wealth." Preliminary estimates suggest a range of wealth from a few thousand to several hundred thousand dollars per capita. The extremes between rich and poor are about the same as for income: annual income flows vary from less than $100 to more than $20,000 per capita, whether the measuring rod is the gross national product (figures for GNP given in the Bank's *Atlas*) or such "green" variants as NNP′, described in chapter 7.

This similarity in ranges is to be expected, in that developing economies are estimated to have nearly a third of the world's natural resources but barely a fifth of the wealth stored in produced assets or human capital. Given the weight of human capital in wealth and the role of income (and land) in estimating this item in the present study, there are also methodological reasons for the similarities. But even these first crude estimates of wealth reveal significant national imbalances among the three forms of wealth: human capital, produced assets, and natural resources.

Figure 8.2 demonstrates a clear tendency for produced assets to account for 15 to 20 percent of the total, regardless of the level of wealth. But if they are not statistical illusions created by weak national accounts, cases where produced assets are well above this level (such as Algeria, Kenya, Libya, Mozambique, Nigeria, Uganda, and former Yugoslavia) would suggest that real growth rates will not improve when produced assets are pushed far above the usual range. Real growth rates in countries where produced assets are below 9 to 10 percent of wealth are not noticeably lower than those in other economies. With few exceptions (notably the Central African Republic), these are nations with impressive endowments of natural capital. While more refined estimates are required to test the point, it does seem that variance in real growth rates can be better explained by how much attention countries have given to human resources than by their acquisition of produced assets.

Produced assets make up only 15 to 20 percent of the wealth of rich and poor nations alike

Figure 8.2. Wealth in produced assets

Source: World Bank.

Figure 8.3 and Table 8.1 indicate significant differences in composition of wealth between high-income and developing economies. Figure 8.3 subdivides developing economies between those most dependent on exporting raw materials to earn foreign exchange and those more oriented toward exports of manufactures, services, and so on. The sizes of the "pies" in figure 8.3 are suggestive of disparities in the global distribution of wealth, although differences are actually more pronounced. With under 16 percent of the world's population, high-income countries have nearly 80 percent of global wealth. Raw-material exporters, with almost as many people, have less than 5 percent of global wealth. Other developing countries, with nearly 70 percent of world population, have barely 16 percent of global wealth.

Based on the Bank's standard country classification, natural capital accounts for nearly 44 percent of total wealth for exporters of primary goods, against 28 percent for all other developing economies and 17 percent for high-income economies. The fact that raw material exporters also seem to have the highest proportion of wealth in produced assets is somewhat surprising and suggests that there is little justification for relatively greater expansions in this area. Clearly the most apparent deficiency for raw material exporters is in human resources.

Raw material exporters have nearly twice the natural capital per capita of other developing countries. But even they are endowed with less wealth in this form than are citizens of high-income economies. Excluding land, which is assumed to rise in value with income, per capita natural capital declines from over $8,000 in high-income economies to under $5,000 for raw material

Raw material exporters rely more on their natural resources than do high-income countries, which rely most on their human resources

Figure 8.3. Composition of world wealth
(Percentage of total)

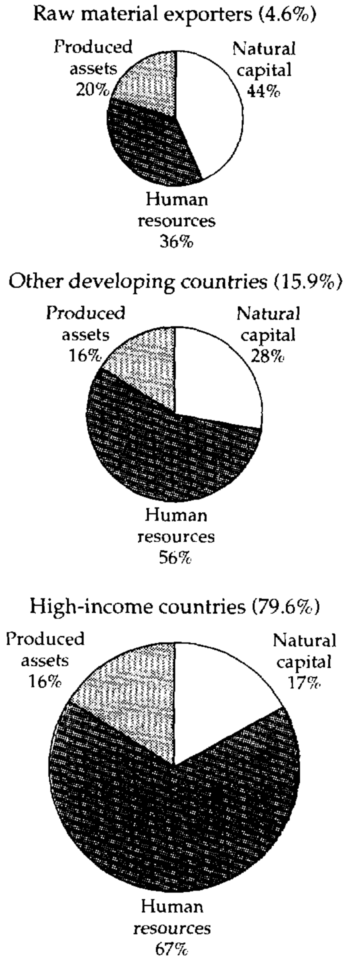


Table 8.1. Sources of wealth by region
(Percentage of total)

	Human resources	*Produced assets*	*Natural capital*
World	64	16	20
High-income countries	67	16	17
Developing countries			
Sub-Saharan Africa	31	17	52
Eastern and southern Africa	33	14	52
Western Africa	25	25	50
India and China	73	18	9
Other Asia	75	13	12
East Asia and Pacific	75	13	12
South Asia	76	16	9
Latin America and the Caribbean	50	15	35
Middle East and North Africa	39	29	32
Eastern Europe	41	16	43

Source: World Bank.

exporters, and under $3,000 for other developing economies.

Countries' differing natural resource endowments are suggested by figure 8.4, which distinguishes countries by the importance natural capital has in the monetary measure of tota wealth. Further studies now under way suggest that a somewhat different picture would emerge if this measure were expressed in per capita or per hectare terms, or if a nonmonetary measure were expressed in either term.

Directions for Further Work

This discussion points the way toward a promising direction for statistical work and is not a completed study. While the broad direction is generally accepted, the underlying concepts have not yet been clearly enough defined to guide empirical work. Further data work would be useful and would inform the debate about which differences actually matter and which are important only in theory.

Valuation tends to be a contentious methodological issue. Monetary valuation is the norm for produced assets and seems unavoidable in a balance sheet covering all three categories of wealth. The pros and cons of monetary valuation, discussed extensively elsewhere, are usually treated in terms of current market prices.[9]

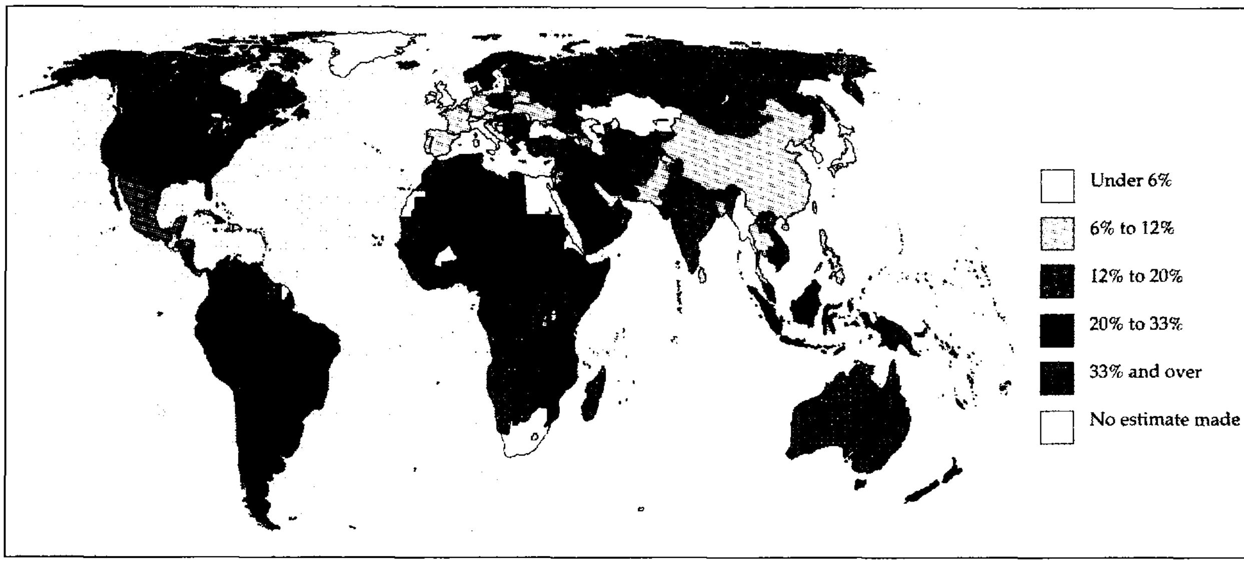
Using current prices simplifies compilation but can give a distorted view of equilibrium prices, particularly in the longer term. If only by removing present distortions, it also downplays the positive role of markets in altering relative prices in the future (see chapter 5). For policymaking the ideal monetary valuation would be one reflecting market prices at the future date when markets would be in equilibrium and policies would have been rationalized. The important debate, then, is about whether some other valuation scheme could provide a better approximation of future relative prices.

Where monetary valuation is difficult, other, nonmonetary indices are often used. Another fruitful area could be further practical testing of how such techniques as multicriteria analysis can be applied to measure the trade-offs among otherwise noncomparable measures.[10]

Nonmonetary valuation is common in measuring natural capital and human resources. Such

Natural endowments are as important for some wealthier countries as for some poorer ones

Figure 8.4. Natural capital as a percentage of total wealth



Source: World Bank.

valuation is often implicit in aggregation and weighting schemes that combine qualitatively different quantities. For example, a measure of mineral extraction that does not use monetary values must still decide how to add tons of ore that differ in mineral content or environmental consequences of extraction. The practical issue is whether and where the results of such schemes differ markedly from those obtained by monetary valuation. Where they do, the a priori preference would seem to be the valuation method that better reflected future relative prices—itself a debatable issue, but one more likely to interest decisionmakers than do theoretical discussions of methodologies. Nor are monetary and nonmonetary valuations always so different. The choice did not seem to matter much, for example, in monitoring relative levels and trends in material through-put (see chapter 4).

For this first iteration of wealth estimates, then, valuation issues are considered only generally. The first-order concern is whether a change in valuation methodology would markedly alter the share in the total assigned to each category for broad groups of countries.

A definitive approach to valuation is bound to be illusive and would detract from the equally important task of collecting basic information, in physical terms, on the quantities to be valued, aggregated, or weighted. Crude valuation methods of the type presented above reveal such glaring gaps as the omission of marine resources from wealth and could lead to more careful thinking about the underlying source for measures of produced assets, that is, conventional national accounts reporting on gross fixed capital formation. Do such accounts really include irrigation and livestock, for example? There may also be value in comparing estimates of educational attainment and future income pool to determine why measures of human resources are significantly different among some countries.

For natural capital as well more work is needed on nonmonetary measures. Exploratory work has been done in this direction by the World Resources Institute (WRI)—notably a composite index prepared for a study by the Global Environment Facility (GEF). The GEF-WRI effort emphasizes a habitat and species approach to natural capital but with the limitation that it ignores the market aspect of natural capital, nature's role in providing raw material inputs for economic activity.[11] It is in this sense that natural capital is a logical counterbalance to the monetary measure discussed above.

Monetary and nonmonetary measures of natural capital both assign value to land based on its use. But the relative values will be quite different, since one emphasizes nature conservation, the other commercial possibilities. For example, the GEF-WRI measure views conversion of grassland to cropland as a negative, whereas the crude monetary measure assumes that a hectare of cropland will generally fetch a better price than one of grassland. There is no real conflict here. Each statement is true in its context. The analytically interesting question is, where do the two valuation schemes differ, and is there a pattern to the differences?

The main message regardless of the measure used is that the larger the share of the earth, the greater its potential natural capital. Measures must therefore be put in perspective in relation to a country's share in global land area or population. Land area is useful in determining how nations differ in the quality of their land, while population allows for the assessment in relation to human resources. Neither approach is inherently right or wrong, and each provides a different perspective.

There can, therefore, be significant misunderstandings about indicators of natural capital, not only in the choice between monetary and nonmonetary values but also when national averages are compared but allowance is not made for differing endowments of land and people. Particularly when considering such issues as land degradation and population growth, these denominator differences can be more significant than the method used to weigh the numerator. Further work on these analytical procedure problems is just as necessary as added information about physical conditions.

Ideally, for a correct valuation of wealth, a fourth category of wealth also needs to be taken into account—social infrastructure. While the full scope and definition of social infrastructure is only beginning to emerge, the term is generally understood to encompass the institutional and cultural basis needed for a society to function. But questions remain not only about how to measure social capital but also whether it is possible to invest in such capital. Further study in this direction, while needed, is beyond the scope of the present effort. (It should be noted that elements of social infrastructure are subsumed in the residual for human resources, as presented above.)

If wealth is the asset side of a nation's balance sheet, what are its liabilities? For developing economies the net international investment position is likely to be recorded on the liability side of the balance sheet. It is the nation's net worth—that is, its wealth reduced by what it owes to nonresidents—that rises with development and declines with unsustainability. The World Bank is exploring this elaboration of the balance sheet envisaged in the UN system of national accounts, using data from its work on external debt and direct foreign investment as well as IMF reports on international banking and balance of payments accounts. In theory financial claims are another category of wealth that nets to zero—that is, assets equal liabilities. But for the present purpose an excess of foreign assets over foreign liabilities would represent a national substitution of financial for tangible wealth. Net foreign liabilities, the usual situation for a developing country, would therefore be recorded as a liability.[12]

Net international investment positions need not be the only adjustment between wealth and net worth. As a practical matter degradation of natural capital not normally marketed, notably air and water, can also be recorded as a liability. Rather than attempting to give a value to these life-supporting assets, such an exercise would be undertaken to avoid overstating net worth where the pursuit of wealth causes the degradation of common property. Showing such degradation as an increased liability permits recognition that a polluting activity may generate new assets—with separate consideration of whether the liabilities involved are more or less offsetting. Since it is mainly future generations whose access to such common property is being encumbered, this additional liability item might be thought of as the net intergenerational investment position.

In summary, crude estimates of a national balance sheet could report on:

Assets	*Liabilities*
Produced assets	International investment (net)
Natural capital	Intergenerational investment (net)
Human resources	
Social infrastructure	Net worth (difference)

Notes

1. This analysis derives from Ismail Serageldin and Andrew Steer, "Epilogue: Expanding the Capital Stock," in *Making Development Sustainable: From Concepts to Actions* (Washington, D.C.: World Bank, September 1994).

2. See chapter 7 in this volume and Kirk Hamilton and John O'Connor, "Genuine Saving and Financing of

Investment." Environment Department, World Bank, Washington, D.C., 1994.

3. United Nations Conference on Trade and Development, *International Accounting and Reporting Issues: 1994 Review* (Geneva: UNCTAD, 1994).

4. Vikram Nehru and Ashok Dhareshwar, "New Estimates of Total Factor Productivity Growth for Developing and Industrial Countries." Policy Research Working Paper no. 1313. International Economics Department, World Bank, Washington D.C., June 1994. See also Vikram Nehru and Ashok Dhareshwar, "A New Database on Physical Capital Stock: Sources, Methodology, and Results," *Revista de Análisis Económico* 8 (June 1993):37–59. Country coverage was expanded for the present study by using outside country studies, an alternative perpetual inventory method, and other gap-filling techniques. For countries for which more than one estimate was available, technical discussion could alter the estimates by 20 to 30 percent.

5. In particular, studies of Mexico and Papua New Guinea in Ernst Lutz, ed., *Towards Improved Environmental Accounting* (Washington D.C.: World Bank/UNSTAT, 1993).

6. Theodore Schultz, *Human Resources* (Cambridge, Mass.: National Bureau of Economic Research, 1972), pp. 8–9.

7. See Vikram Nehru, Eric Swanson, and Ashutosh Dubey, "A New Database on Human Capital Stock: Sources Methodology, and Results." Policy Research Working Paper no. 1124. International Economics Department, World Bank, Washington, D.C., April 1993.

8. See, in particular, Dale Jorgenson and Barbara M. Fraumeni, "The Output of the Education Sector," in Zvi Grilliches, ed., *Output Measurement in Service Sectors* (Chicago: University of Chicago Press, 1992).

9. John Dixon, L. Fallon-Scura, R. Carpenter, and P. B. Sherman, *Economic Analysis of Environment Impacts* (London: Earthscan Publications, 1994).

10. For further details about monetary and nonmonetary measures of environmental assets and the use of multicriteria analysis to trade off among them, see Mohan Munasinghe, *Environmental Economics and Sustainable Development* (Washington, D.C.: World Bank, 1993).

11. E. Rodenburg, D. Tunstall, and F. van Bolhuis, *Environmental Indicators for Global Cooperation*. GEF Working Paper no. 11 (Washington, D.C.: World Bank, 1995).

12. Accountants may well have views on this problem since they have evolved harmonization arrangements toward definitions over the past twenty years in reporting on complex financial arrangements for business enterprises and for capital market use.

CHAPTER 9

How Have the Poor Fared?

Reducing poverty remains a tremendous challenge both for the governments of developing countries and for the World Bank. It is estimated that 1.1 billion people still live in absolute poverty, that is, on less than $1 a day. If current trends continue, this figure will rise to 1.3 billion by the year 2000.[1] If the poverty benchmark is doubled, the estimated number of poor also doubles, indicating that about two of every three people in the developing world together consume less than $2 a day.[2]

Economic trends during the 1980s did little to help the poor. In low- and middle-income countries, GNP per capita rose only 0.9 percent a year, insufficient to reduce the numbers of poor.[3] In essence from 1985 to 1990, the number of poor grew at the same rate as the aggregate population of the developing world—about 2 percent per year.

But such global figures hide the fact that regional disparities have sharpened. While East Asia, for instance, has reduced poverty, the numbers of the poor continue to rise rapidly elsewhere—especially in Latin America and Sub-Saharan Africa (table 9.1). It is not coincidental that in these two regions GNP growth per capita was negative over the decade of the 1980s.

Progress with poverty reduction depends not only on the economic growth rate but also on how growth was generated and how it was shared across the population. Between 1960 and 1980 Brazil, for example, achieved a 220 percent increase in per capita income, but this led to only a 34 percent decline in the headcount index of poverty. By contrast in Indonesia, where income per capita grew 108 percent from 1971 to 1987, the poverty incidence was reduced 42 percent. Reasons for this difference include Brazil's less equal initial income distribution and the broader-based growth achieved in Indonesia.[4]

Table 9.1. Estimating poverty in the developing world, 1985 and 1990

	Number of poor (millions)		*Headcount index (percent)*		*Poverty gap index (percent)*	
Region	*1985*	*1990*	*1985*	*1990*	*1985*	*1990*
Aggregate	1,051	1,133	30.5	29.7	9.9	9.5
East Asia and the Pacific	182	169	13.2	11.3	3.3	2.8
Eastern Europe	5	5	7.1	7.1	2.4	1.9
Latin America and the Caribbean	87	108	22.4	25.2	8.7	10.3
Middle East and North Africa	60	73	30.6	33.1	13.2	14.3
South Asia	532	562	51.8	49.0	16.2	13.7
Sub-Saharan Africa	184	216	47.6	47.8	18.1	19.1

Source: World Bank, *Implementing the World Bank's Strategy to Reduce Poverty: Progress and Challenges* (Washington, D.C.: World Bank, 1993).

In some African countries declines in average income have been accompanied by dramatic rises in poverty. In Côte d'Ivoire GDP per capita fell 13 percent between 1985 and 1988, and poverty incidence went up from 30 to 46 percent. The increase in poverty would have been even more dramatic if the income decline had affected all income groups in the same way, but in this case the decline mostly affected those with higher incomes.[5]

The Bank's basic strategy for poverty alleviation has evolved over the years based on country experience. *World Development Report 1990* outlined a two-part strategy of promoting broad-based growth using the poor's most abundant asset—labor—while providing basic social services to the poor. Targeted social safety nets aim to help the poor, old, or disabled who are not reached by economic growth.

Poverty Indicators

Poverty is conventionally measured by the income or expenditure level that can sustain a minimum standard of living. The headcount index shows the proportion of population whose income or consumption is below this minimum. The poverty gap measures the extent of the shortfall, usually as a percentage of the poverty line. Poverty indexes that put more weight on the condition of the poorest people are also available.

But poverty, which is fundamentally multidimensional, must also be described in terms of the degree to which basic needs—education, health, housing, safe drinking water, sanitation, and a clean environment—are fulfilled. This makes it imperative for poverty indicators to extend beyond consumption-based measures to cover school enrollment, infant mortality, life expectancy, environmental quality, and other such indicators as well.

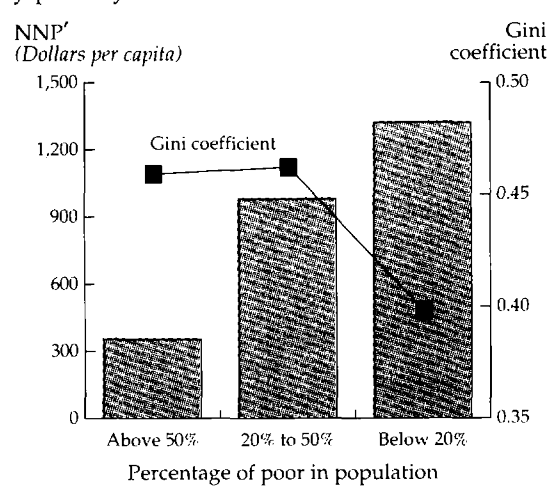
In terms of indicators poverty must be viewed both as a household and individual attribute and as an attribute of nations. There are myriad interactions between the macroeconomic and microeconomic levels, and indicators need to capture both the country situation and that of households and individuals within a country.

The two basic indicators for consumption-based poverty are the Gini coefficient (G), which summarizes the entire distribution of consumption or income, and the headcount index, which measures the percentage of the population consuming less than $1 a day. Figure 9.1 shows that NNP′ (NNP′ is net national product adjusted to reflect depletion of natural resources and global damage from carbon emissions; see chapter 7) per capita is almost three times higher in countries with an intermediate incidence of poverty (20 to 50 percent) than it is in countries with a high incidence of poverty (more than 50 percent). This underlines what most policy analysis has shown—economic development is a prerequisite for sustained poverty reduction.

The figure also shows that initial reductions of absolute poverty can occur without reductions in overall inequality. Only countries with absolute poverty levels below 20 percent show systematically lower levels of inequality, as represented by low Gini coefficients. The level of inequality can be used to estimate the welfare loss in society arising from inequality. In its simplest form this welfare loss can be estimated by reducing GNP (or NNP′) by (1–G), which gives the distribution-corrected "real national income."[6] Country rankings can change when one moves from GNP to distribution-corrected GNP. For example, downward shifts in ranking occurred in the cases of Brazil, Guatemala, and Honduras (all countries

Per capita income in countries with intermediate poverty is almost three times higher than in countries with a high incidence of poverty

Figure 9.1. NNP′ per capita and Gini coefficients by poverty incidence



Note: NNP′ is net national product adjusted to reflect the depletion of natural resources and global damage from carbon emissions. Poverty incidence is calculated as the percentage of the population consuming less than $1 a day in purchasing power parity terms.
Source: World Bank.

with a high degree of inequality), while Poland (with little inequality) moved up five ranks.

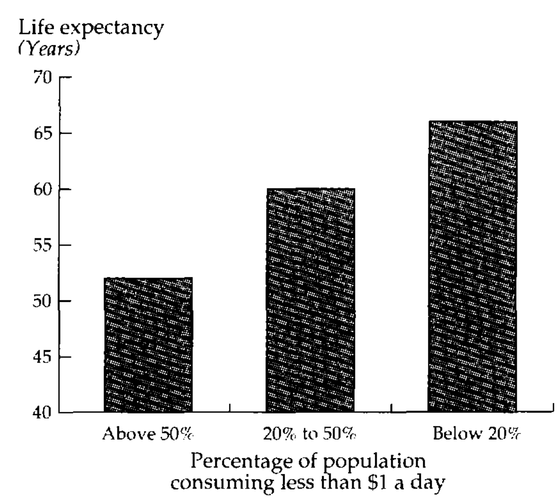
A fairly large number of country-level indicators is available to capture the nonconsumption dimensions of poverty. The World Bank regularly publishes these in *Social Indicators of Development*. Figure 9.2, for example, shows that life expectancy is significantly lower in countries where poverty incidence is high. Similar graphs could show how access to safe water, children's nutritional status, and other indicators are dimensions of absolute poverty at the country level.

Chapter 8 explained how each country's wealth can be measured by valuing produced assets, natural capital, and human resources. Figure 9.3 relates this measure of wealth to the incidence of poverty. At low levels of wealth (less than $20,000 per capita), the relation between wealth and poverty is weak, reflecting both the degree of potential wealth that remains untapped and the poor's lack of access to the benefits generated by the wealth that is available. This is essentially the same story that emerges with income measures.

There is also an analytically interesting pattern of how wealth and its components change with poverty incidence. Figure 9.4 relates poverty to per capita wealth, with countries grouped according to incidence of poverty. In figure 9.1, which relates poverty to NNP', NNP' increases

Life expectancy is significantly lower in countries with a high incidence of poverty

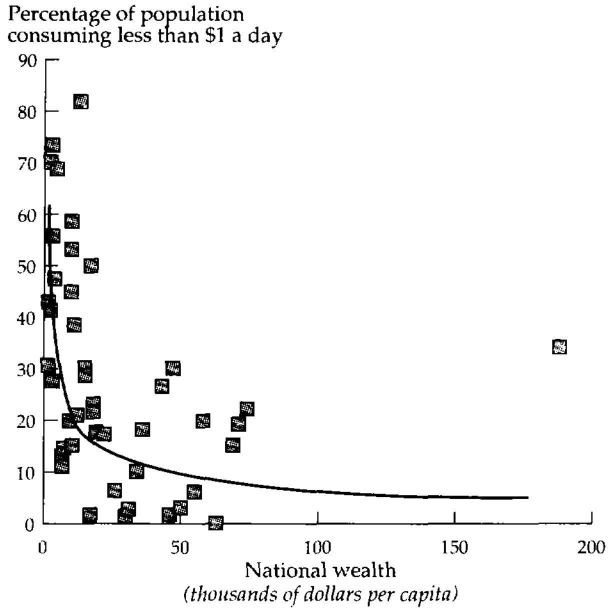
Figure 9.2. Life expectancy in relation to poverty incidence, 1990



Source: World Bank.

In poorer nations the relation between national wealth and incidence of poverty is weak

Figure 9.3. National wealth and poverty incidence, 1990



Note: Estimates of poverty incidence are based on purchasing power parities.
Source: World Bank.

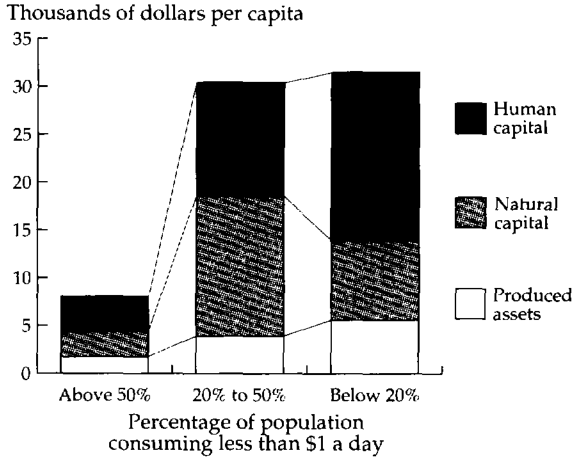
stepwise as poverty incidence declines from high to intermediate and then to low. By contrast, when wealth estimates are used, as in figure 9.4, there is a sharp jump from high to intermediate incidence. This appears to be due to an exceptionally large proportion of wealth in natural capital in countries in the intermediate range. More work will be required to understand this apparent anomaly.

Just as poor countries do not fare as well as wealthier nations in terms of indicators such as access to safe water and life expectancy, poor people within a given country score lower on these indicators than do the nonpoor. Knowledge of these gaps separating the poor from nonpoor should form the basis for setting national priorities and targeting poverty alleviation efforts. But unfortunately the needed data is frequently lacking, and many countries do not have breakdowns of their national-level indicators by poverty category.

Since 1980 the World Bank has invested in improving data collection for measuring levels of living and poverty through the Living Standards Measurement Study (LSMS) and the Social Dimensions of Adjustment (SDA) Program. The LSMS has sponsored over a dozen household

The sharp jump in wealth estimates for intermediate countries may reflect large reserves of natural capital

Figure 9.4. Wealth components by poverty incidence, 1990



Note: Estimates of poverty incidence are based on purchasing power parities.
Source: World Bank.

surveys worldwide, and the SDA program has supported surveys in about twenty-five African countries. These can provide detailed breakdowns (by regions, socioeconomic group, poverty status, and so on) of a wide array of indicators. Results of these exercises are now regularly included in *World Development Indicators,* and a special set of household welfare indicators for selected countries appeared in *African Development Indicators 1994–95.* Several of these surveys were set up as monitoring tools and are repeated each year, or at regular intervals, to assess how living conditions of the poor are affected by changing macroeconomic conditions and policy reform.

Table 9.2 shows the results of a case study of Côte d'Ivoire. From 1985 to 1988 the economy was in serious decline and the fulfillment of basic needs deteriorated badly, particularly for the poorest people in the country. During this period the primary school enrollment of girls in very poor households, for instance, declined from 22.4 to 16.7 percent. In contrast, girls' enrollment in nonpoor households rose. Children in many poor households were pulled out of school to help with the family farm or enterprise, resulting in an age-grade mismatch in primary school. (A mismatch occurs when a child is at least one year behind the grade normally associated with his or her age.) While mismatches increased in number across all poverty groups between 1985 and 1988, they rose far more sharply for the poor and very poor.

In fact all basic needs indicators considered by the case study were found to be significantly lower for the poor than the nonpoor, and lowest of all for the very poor. The majority of the indicators also deteriorated more for the poorest—with the notable exception of preventive health care (mainly immunizations), suggesting that targeted

Table 9.2. Basic needs indicators for Côte d'Ivoire by poverty status and gender, 1985 and 1988

	1985			*1988*		
Indicator	*Very poor*	*Mid-poor*	*Nonpoor*	*Very poor*	*Mid-poor*	*Nonpoor*
Education						
Net primary school enrollment rate[a]						
Male	31.7	51.1	66.3	31.0	54.3	74.1
Female	22.4	41.0	54.0	16.7	41.9	57.7
Age-grade mismatches in primary school[a]						
Male	38.0	30.1	28.5	63.9	48.7	37.3
Female	27.8	27.4	33.3	52.9	47.9	37.7
Health						
Ill people who consulted a doctor or nurse[b]						
Male	31.2	36.9	48.6	19.1	32.8	52.6
Female	30.2	36.2	50.8	16.2	31.3	54.8
Preventive consultations[b]						
Male	14.2	17.1	23.5	40.0	31.4	26.0
Female	15.6	18.1	25.8	47.3	35.9	32.8
Housing						
People with access to electricity[c]	14.1	19.4	46.9	10.9	29.2	53.3

a. Percentage of total enrollment.
b. Percentage of total ill.
c. No gender breakdown available; percentage of total population.
Source: C. Grootaert, "The Evolution of Welfare and Poverty under Structural Change and Economic Recession in Côte d'Ivoire, 1985–88." Policy Research Working Paper no. 1078. African Technical Department, World Bank, Washington, D.C., January 1993.

programs can have a major impact in improving aspects of poor people's lives. This case study also confirmed that increases in measured poverty incidence are only part of the story. The condition of the poor frequently worsened as well.

Poverty and the Environment

Since poverty is now seen as both a consequence and a cause of environmental degradation—improvements in environmental quality should help to reduce poverty and vice versa.

Lacking the means to relocate to areas with clean air or to lobby for better access to water and sanitation, the poor bear the brunt of rising pollution. Their poor nutritional status renders them more susceptible to the health effects of declining environmental quality. Poor women and children face respiratory illness from biomass smoke in their indoor environment. Rural women, feeling the effects of receding forest cover and underground water reserves, must travel farther and spend more time collecting water and fuelwood. The declining natural resource base exacerbates the condition of the poor by limiting their already restricted production possibilities. As production possibilities diminish and population pressures rise, limited possibilities are overexploited triggering a process of cumulative causation where poverty and degradation feed into each other.[7]

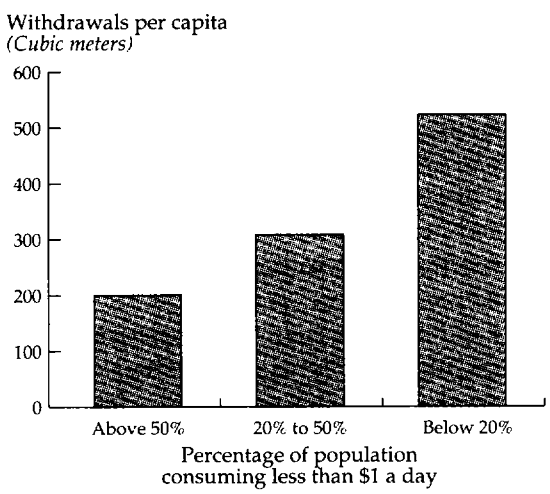
The relation of poverty to the environment also needs to be evaluated at the country and household levels. Figures 9.5, 9.6, and 9.7 relate selected environment indicators (water, health, and pollution) to the national incidence of absolute poverty. Figure 9.5 shows that freshwater withdrawals rise with falling poverty. This is, in effect, a reverse indicator of the fact that the poor have less access to piped water. But given its broad correlation with poverty, the importance of policy in this area must not be overlooked.

Even in the same bracket of poverty incidence, per capita water withdrawals can vary substantially. A striking example is the effect that water supply tariffs have had on consumption of water in former East Germany. Since 1989 average daily consumption in the eastern part of Germany has dropped from an estimated 300 to 400 liters per capita to about 105 liters per capita.[8]

Chapter 3 noted that the incidence of respiratory and diarrheal diseases is greater in poorer regions, such as Sub-Saharan Africa. Other aspects of health—such as malnutrition—are also affected by environmental degradation, most particularly by the declining quality of agricultural land. Figure 9.6 shows that the

As poverty incidence decreases, freshwater withdrawals increase

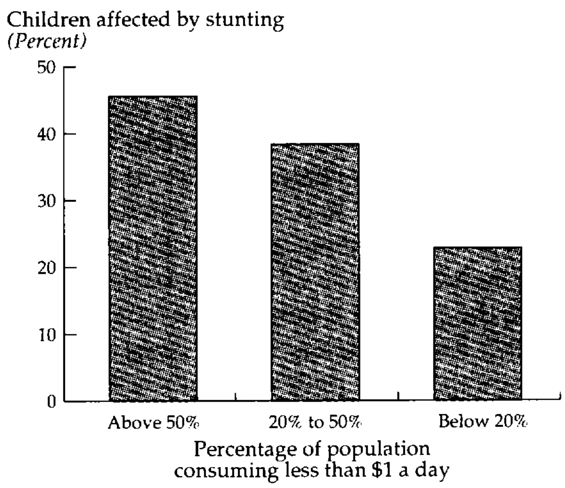
Figure 9.5. Freshwater withdrawals by poverty incidence, 1970–92



Note: Withdrawal data are for single years between 1970 and 1992 and vary from country to country. Poverty incidence data are for 1990. Estimates of poverty incidence are based on purchasing power parities.
Source: World Bank and World Resources Institute.

The percentage of young children affected by stunting decreases as poverty incidence declines

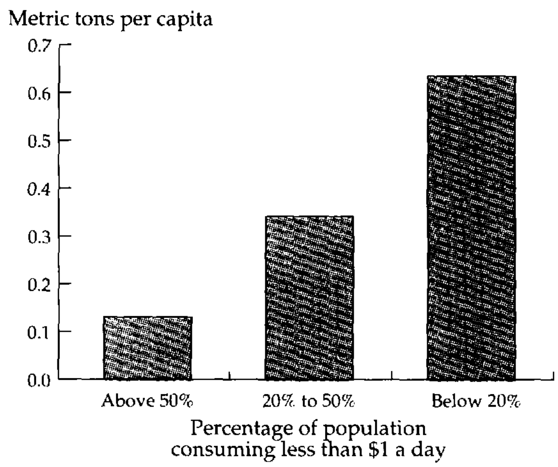
Figure 9.6. Nutrition and health behavior by poverty incidence, 1980–90



Note: Stunting is defined as low height for age. Data are for children age 24 to 59 months.
Source: World Bank and World Health Organization.

Carbon dioxide emissions per capita are significantly higher in countries with poverty incidence below 20 percent

Figure 9.7. Carbon dioxide emissions per capita, 1990



Source: World Bank.

percentage of young children whose growth is stunted is twice as high in the poorest as in the least poor countries (although nonenvironmental factors are also a cause).

Regarding air pollution, as chapter 6 pointed out, the rich world emits carbon dioxide at rates ten to twenty times higher than those in the developing world. Figure 9.7 shows that carbon dioxide emissions per capita from fossil fuel combustion also vary among developing countries and are, as expected, significantly higher in countries with the lowest poverty rates.

While rates of deforestation (see chapter 1) are not systematically related to poverty at the country level, there is evidence that the existing net fuelwood supply is lower in poorer countries. In Africa in 1980 countries with the lowest poverty incidence had an average fuelwood supply-demand balance of 36.6 million cubic meters. Those with intermediate poverty rates had an average balance of only 4.5 million cubic meters, while in the poorest countries the balance was negative.[9] The evidence further suggests that within countries the poor must go increasingly farther distances and spend ever more time gathering fuelwood.

As was the case with basic needs indicators, data on environmental indicators are much scarcer at the household than the national level. The household surveys of the LSMS and the SDA programs would be suitable vehicles to extend coverage of environmental quality indicators. Most of the available information currently pertains to health and sanitation. For example, the Côte d'Ivoire case study found that only one in four very poor households had adequate sanitary facilitates, as opposed to more than 60 percent of nonpoor households. Over time access has improved for the nonpoor but declined for the poor. Garbage removal by truck was available to only 5 percent of the poorest households as against 38 percent of the nonpoor.[10]

A study of seven cities (Accra, Jakarta, Katowice, São Paulo, Singrauli, Tianjin, Tunis) found that the poor suffer disproportionately from urban environmental insults because of their physical location, inadequate access to health care, poor environmental infrastructure, poor quality of services, and overcrowding.[11] Environmentally hazardous areas, for instance, are often inhabited by the poor because they fetch a lower market price. In addition the poor pay more for basic environmental services and infrastructure. The study confirmed the need for targeted interventions to improve the environmental conditions of the poor, citing the examples of improved solid-waste collection and sanitation services in low-income neighborhoods in Accra and slum upgrading in Jakarta. There is clear evidence that such interventions should form part of nations' overall strategy to alleviate poverty.

An important dimension of the two-way link between poverty and the environment, especially in rural areas, is the condition of common property resources. Many poor depend on such common resources as forests, grazing lands, irrigation systems, and fishing grounds. Deforestation, soil erosion, desertification, and other forms of environmental deterioration have diminished the incomes of many rural poor and increased their vulnerability. Because poverty limits people's options and induces them to deplete resources at a more rapid rate than is compatible with long-term sustainability, the poor themselves aggravate the process of environmental degradation.

Primary factors influencing this vicious circle are the management practices and ownership of common property resources. It is often the collapse of traditional management systems that converts them into open-access resources. Ill-defined or ill-enforced private property rights, or ineffective state management, can also result in excessive use, which will eventually make everyone worse off. By the same token effective cooperative management by stakeholders can halt—or even reverse—such erosion. Among other factors that have been shown to contribute to successful cooperative management are internal homogeneity of the user groups and vesting stakeholders with real responsibility for management. Cooperative local management can both improve the condition of common resources (such as irrigation systems) and increase returns to investment in them.[12]

The issue of self-management has been investigated empirically through case studies, an approach that poses difficulties for monitoring this aspect of the poverty-environment link. The environmental indicators discussed elsewhere in this report give a rough sense of the state and change of common resources. A more challenging task would be to capture the effect of imperfect management regimes as the force driving the downward spiral of poverty and environmental degradation. Bearing in mind their location-specific nature, findings of case studies need to be systematized and specific indicators developed to capture property rules, management arrangements, and stakeholders' degree of effective participation and control. These tasks are essential for monitoring social sustainability.

Social sustainability of development is an integral part of environmental sustainability. Social development indicators are therefore needed to complete the picture for the monitoring of poverty and environment. These indicators should reflect the extent to which the poor participate in the process of economic decisionmaking in the development initiatives that affect them. The different stages in this process include identifying stakeholders, bringing them together to express priorities, intermediating between the poor and the authorities, getting financial resources needed for implementation to the poor, and monitoring project implementation. While indicators could be developed for each stage, most that have been used so far pertain to financial resources and implementation.

National-level performance indicators include the share of development funds under the control of local authorities and the amount of social funds set up to finance local projects. Project-level indicators include, among others, the number of visits made to health clinics, the amount of loans taken out by farmers with small landholdings, and the number of acres planted with drought-resistant, high-yielding varieties. But while these reflect popular participation to some extent, they do not reveal participation in decisionmaking. Gross measures of participation are memberships in relevant organizations, attendance at meetings, and payment of dues.

All of these measures need to be supplemented with information on the extent of initiatives from and problem-solving by local groups, which indicators cannot readily capture and is best approached through other evaluative methods.[13] A study evaluating 121 rural water supply projects[14] relied on twelve indicators to assess the role of participation across different stages of the project cycle in determining project success. The indicators focused on the extent to which community institutions existed and functioned and the degree to which women participated in them. The results suggest that participation increased project effectiveness, even after controlling for other direct and indirect determinants of outcomes.

Popular participation is one aspect of the wider notion of social capital, which refers to social values and norms, institutional arrangements, and people's attitudes and capacities—all of which influence the process of development and determine its ultimate sustainability. Poverty depletes social capital and reduces social sustainability. A direct indicator of this fact is the reduced range of production and consumption options open to communities that face worsening conditions of natural resources.[15]

Directions for Further Work

Adequate monitoring of the poverty-environment nexus, including the social dimension, will take time. Recognizing the need for indicators at the country as well as at the household level, three lines for future work emerge.

At the microeconomic level, the challenge is to link household dimensions of poverty to environmental information, which often applies to geographic entities such as countries, regions, villages, and so on. A fruitful source of such data is satellite imagery, and more work is needed to combine this information with household survey information on poverty. This could be done both through overlay maps generated using a geographic information system and econometric estimations of household models that include the environmental dimension. Ideally this approach can be used to highlight both directions of causality in the poverty-environment vicious circle so as to determine, first, how impoverishment adds to environmental degradation and second, which aspects of the latter constitute impediments to the escape from poverty. A supplementary task is to identify a set of environmental variables that could be collected to enhance future poverty and environmental analyses.

One product of this first line of work would be a set of indicators of observable characteristics at the household or village level that are good predictors of poverty and that would therefore be suitable targets for poverty alleviation programs. Based on observable asset holdings, housing conditions, and so on, existing experimental work has achieved about a 60 percent success rate in identifying households in poverty. But the role of environmental conditions has not yet been considered. Given the strong link between poverty and environment, good predictors for one dimension could be used for the other as well.

At the macroeconomic level, the relation between poverty and environment needs to be explored beyond the simple correction of national product and wealth estimates with the Gini coefficient. A multivariate approach—whereby country-level poverty is estimated econometrically as a function of wealth components, economic growth, distribution, and so on—holds promise. (Such work underlies the Bank's current estimates of global poverty.)

Finally the social dimension of the poverty-environment interaction needs to be spelled out further. The notion of social capital needs to be operationalized and indicators developed that are subject to systematic data collection. Bank experience with participation in projects as well as economic and sector work—especially participatory poverty assessments—provides a basis for further work.

Notes

1. World Bank, *Poverty Reduction and the World Bank: Progress in Fiscal 1993* (Washington D.C.: World Bank, 1994.)

2. S. Chen, G. Datt, and M. Ravallion, "Is Poverty Increasing in the Developing World?" *Review of Income and Wealth* 40 (December 1994).

3. World Bank, *World Development Report 1994* (New York: Oxford University Press, 1994).

4. World Bank, *Implementing the World Bank's Strategy to Reduce Poverty: Progress and Challenges* (Washington, D.C.: World Bank, 1993).

5. C. Grootaert, "The Evolution of Welfare and Poverty under Structural Change and Economic Recession in Côte d'Ivoire, 1985–88." Policy Research Working Paper no. 1078. Africa Technical Department, World Bank, Washington, D.C., 1993.

6. A. Sen, "Real National Income," *Review of Economic Studies* 43(1976): 19–39.

7. The relationship between environment and poverty is explored more fully in World Bank, *World Development Report 1992: Development and the Environment* (New York: Oxford University Press, 1992).

8. J. Briscoe, "The German Water and Sewerage Sector: How Well It Works and What This Means for Developing Countries." Transportation, Water, and Urban Development Department, World Bank, Washington, D.C., 1995.

9. K. Cleaver and G. Schreiber, *Reversing the Spiral: The Population, Agriculture, and Environment Nexus in Sub-Saharan Africa* (Washington, D.C.: World Bank, 1994), table A-21.

10. C. Grootaert, "Evolution of Welfare," pp. 90–92.

11. J. Leitmann, "Rapid Urban Environmental Assessment: Lessons from Cities in the Developing World." Urban Management Programme Discussion Paper no. 14. World Bank, Washington, D.C., 1993.

12. For a further discussion of common property resource issues, see also R. Kanbur, "Heterogeneity, Distribution, and Cooperation in Common Property Resource Management." Policy Research Working Paper no. 844. Office of the Vice President of Development Economics, World Bank, Washington, D.C., 1992; and P. Bardhan, "Research on Poverty and Development Twenty Years After Redistribution with Growth," and E. Ostrom, "Incentives, Rules of the Game, and Development," presented at the Annual Bank Conference on Development Economics, May 1–2, 1995, Washington, D.C.

13. N. Uphoff, "Monitoring and Evaluating Popular Participation in World Bank–Assisted Projects," in B. Bhatnagar and A. Williams, eds., *Participatory Development and the World Bank.* World Bank Discussion Paper no. 183 (Washington, D.C.: World Bank, 1993).

14. Deepa Narayan, *The Contribution of People's Participation: Evidence from 121 Rural Water Supply Projects.* Environmentally Sustainable Development Occasional Paper Series no. 1 (Washington, D.C.: World Bank, 1995).

15. N. Jodha, "Social Sustainability: A Framework for Understanding and Operationalizing the Sustainability Issues for ESD." Environment Department, World Bank, Washington, D.C., 1994.

APPENDIX

Technical Notes

Making progress toward environmentally sustainable development will be a complex and multidimensional process; measuring this progress presents challenges to match. This edition of *Monitoring Environmental Progress* highlights a selection of aggregate indicators that were chosen for their policy relevance as well as more pragmatic considerations, such as the availability of roughly comparable cross-country data. The themes and indicators selected fit into a larger process. This process is described below first as a global effort for compilation and dissemination of environmentally sustainable development indicators and then as a consensus framework for near-term compilations at the national level.

From the institutional perspective, Bank efforts are part of a global coalition that is steadily improving environmentally sustainable development indicators. This publication relies heavily on pioneering work by others and has been shaped with an eye to works in progress elsewhere. From the compiler's perspective, guidelines are still needed on how to organize near-term work on environmentally sustainable development indicators. This has led to the development of a provisional framework that should at least distinguish true information gaps from areas where refinement of existing statistical activities may suffice.

Given the right institutional and compilation foundations, indicator work can be viewed as an intermediate step needed to produce such higher-level products as models that probe the trade-offs among economic, social, and ecological concerns and succinct, policy-oriented indicators. Such goals, while beyond the reach of this first edition, should figure prominently in future editions.

These technical notes conclude with data notes and a description of the components and methods used to construct the indicators appearing in the body of the report. Bibliographic references and indications of further documentation available from the Bank are provided here as well.

The Indicator Framework

The starting point for the proposed provisional framework was the indicator work done by the OECD, which first laid out a useful set of criteria for the selection of indicators:

Policy relevance

- Indicators should be easy to interpret.
- They should show trends over time.
- They should be responsive to changes in underlying conditions.
- A threshold or reference value must be established against which conditions can be measured.

Analytical soundness

- Indicators should be well founded in technical and scientific terms.

Table A.1. Sustainability matrix

Issue	*Agenda 21 chapter*	*Driving force indicator*	*State indicator*	*Response indicator*
Environmental				
Sources		*Resource depletion index X	....	....
Water (excluding oceans)	18	Withdrawal/availability	Water use/population	*Water charges/costs of provision*
		....	Biological oxygen demand and chemical oxygen demand in water	....
				....
Fisheries	–	**Catches of marine species*	....	....
Forests	11	*Roundwood production*	*Forest area/total area*	Reforestation rate
		Deforestation rate	Standing timber ❖	*Stumpage fees/price of timber* ❖
		....	*Quality of forest cover ?	....
Land				
Land management	10	*Land use changes	**Human-induced soil degradation*	*Land management techniques ❖
		....	*Soil erosion risk index ❖	....
Agriculture and rural development	14	Arable land per capita	*Cropland/natural capital* ❖	Rural to urban terms of trade
		*Use of fertilizers and pesticides X	Area with salinization or waterlogging	Expenditures on extension services ?
Deserts and droughts	12	Fuelwood consumed per capita	*Desertification index ?	....
Subsoil assets	–	*Material inputs/GNP* ❖	*Subsoil assets/wealth* ❖	**Prices of inputs to outputs* ❖
		*Extraction rates	Years of proven reserves	Energy taxes and subsidies
		Energy consumption per capita	....	Renewable/nonrenewable resources ?
Sinks		*Pollution index X		
Solid waste	21	Industrial and municipal waste X	Waste disposal/waste generation X	Expenditures on waste collection ❖
Toxics	19, 20, 22	*Generation of toxics ❖	*Area of contaminated land ?	.... ?
Greenhouse gases	9	**Carbon dioxide and methane emissions*	*Carbon dioxide and methane in atmosphere	Expenditures on abatement ❖
Stratospheric ozone	9	Production of CFCs	CFCs in atmosphere	Programs to phase out ozone-depleting substances
Life support		*Ecosystem risk index X		
Biodiversity	15	**Rate of habitat loss* X	**Natural capital/wealth* ❖	*Protected area/total land area*
		*Rate of species extinction ?	*Number of threatened species	Protected areas/sensitive areas ❖
Oceans and coastal zones	17			
Human health impact	6	*Index of environmental impact ❖		
Water quality and access	6	Household water use per capita	Access to safe water	Percentage of population with sanitary services
		....	Fecal coliform	....
		....	*Lead in water ?	....
Air quality	6	**Pollution load* ❖	**Ambient concentrations* ❖	....
Other	6		*Environment-related diseases ?	....
Social				
Demographics	5	Rate of population growth	Population density	Fertility rate
Health	6	*Burden of disease (DALYs)* ❖	Life expectancy	Health expenditures/GNP
		Calorie intake per capita	Infant mortality rate	....
Education	16	School enrollment	Adult literacy rate	Education expenditures per capita
		....	*Educational Attainment* ❖	....
Human settlements	7	Rate of urban population growth	Percentage of total population in urban areas	.... ?
Housing	7	....	*Shelter index ?	Housing expenditures/GNP
		....	Marginal settlements ?	....
Infrastructure	7	Motor vehicles per capita	....	Infrastructure expenditures/GNP
Economic				
Poverty	2, 3, 4	*GNP/population growth rate*	*Headcount and poverty gap indices*	Labor-intensive growth ?
		Distribution of wealth	*Genuine saving/GNP* ❖	Targeted interventions
		*Production-consumption patterns ?	Net primary school enrollment rate by poverty status and gender	
		Total fertility rate	Infant mortality rate	Expenditures for basic social services/total public expenditures
			Percentage of population using family planning	
Financial resources	33	Per capita wealth	Environmental protection expenditures per capita ?	Investment/GNP
		....	....	*Environmental taxes + subsidies/GNP* ?
		....	....	New environmentally sustainable development funding ?
Transfer of technology	34			
Productivity	–	NNP'/wealth ❖	*NNP'/GNP* ❖	*Intermediate inputs/GNP* ❖
		Unemployment rate	Manufacturing/GNP	Capital/output ratio ❖
Institutional	8, 38–40	.... ?	*Mandated environmental assessments ?	*Ratification of international conventions ?

Note: * = composite index; ❖ = no internationally agreed compilation procedure exists but some work has been done; X = sources and methods suggested but no compilation done; ? = unsure how to do compilation; ······ = basic indicator research needed.

Measurability

- Indicators should be calculated from data that are readily available or available at reasonable cost.
- Data should be documented and of known quality.
- Data and indicators should be updated at regular intervals.

All of these considerations played a part in choosing the indicators for this report. As discussed below, the actual framework developed by the OECD as follow-up is also a useful starting point for a provisional global approach.

Indicator Sets

Since environmentally sustainable development is multifaceted, the immediate problem the compiler faces is how to structure a coherent indicator set. As a working hypothesis the OECD has adopted an approach that has gained wide support: the pressure-state-response framework. *Pressure,* or *driving force,* indicators measure the extent of human-induced influences on the environment (typically in the form of rates of pollution emissions and often involving extraction and harvest rates). *State* indicators measure the condition of the environment that results from these pressures (including ambient concentrations of pollutants, percentage of natural area that is undisturbed, and so on). *Response* indicators relate to societal responses to the perceived environmental problems (including new regulations, introduction of pollution charges, and so on).

Some have suggested an *impact* indicator category as well to reflect effects of environmental change on specific functions of the environment (such as the support of human health, fresh water availability, or climate stability), for example, work done by the UN Statistical Division in its *Framework for the Development of Environment Statistics.*[1] At this early stage of design and monitoring, most of the significant aspects of the theme or problem may be captured by a set of driving force, state, and response indicators. But impact indicators will be more important as one looks across issues—as, for instance, for national environmental action plans.

The OECD framework presents driving force, state, and response indicators as "columns" in a vector or matrix where the "rows" are environmental issues. This column-row structure is mainly a way to catalog available and proposed indicators and to provide some loose ground rules for summarizing them. The OECD then constructs "time lines" for each issue, identifying indicators that can be compiled in the near term, those planned for the medium term, and longer-term—or ideal—indicators.

The sustainability matrix presented here (table A.1) begins with the OECD's list of environmental indicators for near-term work, then extends it so that it is a more comprehensive listing of issues important to Bank borrowers (such as noting the issue of deserts and droughts). In order to be comprehensive without being exhaustive, it also uses a hierarchical, or nested, approach to issues (such as clustering desert and drought indicators with those for agriculture under a general heading for land). This also turns the framework into guidelines for compiling and summarizing indicators. Indicators should not be combined across columns, since that would be mixing cause and effect. Nor should some indicators from distinct issue clusters be combined while others are ignored.

The clustering of issues in the matrix should be seen as suggestive rather than a concrete framework. Different users may devise variants to suit their immediate needs. But adopting the guidelines suggested above for compilation and summarization routines would facilitate cross-fertilization, not only at the analytical but also at the information-management level. The not-too-distant future might see a common set of detailed indicators with defined aggregation routines generating distinct sets of higher-level analytical indicators.

In the World Bank's variant, the OECD framework is applied to four general areas of concern (environmental, social, economic, and institutional). The recasting of socioeconomic indicators to fit the OECD's framework for environmental indicators is an innovative and perhaps provocative idea. The more conventional approach is to recast environmental indicators to fit the analytical framework for socioeconomic indicators—the UN's system of national accounts (SNA). This is done, for example, in a proposed system for environmental and economic accounts (SEEA), which will continue to get more attention from compilers. Other users may appreciate the issue-oriented approach used in the sustainability matrix proposed here. Moreover, there can be analytical as well as practical gains from focusing more mature and structured indicator systems, like the SNA, on a few issues relevant to sustainable development studies rather than waiting until experts in new areas such as ecology learn enough about the SNA, and so on, to fit their work into existing frameworks.

Harmonizing these two broad approaches to indicator work, then coordinating work across the many issues, will be a major challenge. Refining the sustainability matrix will require active participation from specialists in the subjects represented by each row. This in turn will require channels for communication. Considerable progress has already been made, including the mapping of the indicator tasks to chapters of the UNCED's *Agenda 21*.[2]

As follow-up to the discussion of indicators at its April 1995 meeting, the United Nations Commission on Sustainable Development (CSD) has approved a work program in three phases that reflects the emerging international consensus in favor of the driving force-state-response framework. The CSD has begun the process of preparing detailed methodology sheets for the set of indicators given in a variant of the sustainability matrix. While other international agencies will be taking the lead on specific environmental indicators, Bank staff will be active on all the working groups involved, and the Bank-sponsored Conference on Environmentally Sustainable Development can provide a forum for continuing the indicator dialogue in the periods between CSD meetings.

Many of the indicators of environmentally sustainable development presented in this report are used in the sustainability matrix, where their relationship to a larger structure is made clear. For example, figure 3.2a shows ambient concentration indicators relating to suspended particulate matter —a major factor for air pollution—while figure 3.2b shows pollution load indicators. (Italicized entries in the matrix are items for which actual indicators are given in this report.)

In some cases (such as subsoil assets as a percentage of wealth) italicized entries refer to more broadly defined measures (such as natural capital as a percentage of wealth) quantified in chapters of this report.

Extensive technical documentation now in preparation will detail sources and methods for the empirical base used here. This companion volume—*GAEA, the Global Approach to Environmental Analyses*—will be a precursor to the wider dissemination of the data base underlying this report in electronic form. It will provide a detailed description of the components and methods used to construct the indicators that appear in *Monitoring Environmental Progress*. Documents in progress cover the following areas:

- Distribution-corrected GNP and wealth
- Saving and wealth
- Rental rates for minerals and crude oil
- Carbon dioxide and other greenhouse-gas emissions
- Tax and subsidy rates
- Metals and minerals (consumption)
- Suspended particulate matter (hypothetical generation)
- Forest cover and rates of change.

The matrix is also the framework for a work plan on indicators at the World Bank. Many of the candidate indicators need to be refined and tested, a process that will undoubtedly produce changes in the matrix. For example, Bank staff are playing a leading role in work on land quality indicators —and coordinating this with such related efforts as the World Soils and Terrain Digital Database's (SOTER) global scheme for classifying soils and terrains)—and, with the U.S. Environmental Protection Agency, are supporting efforts by the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) to provide more policy-oriented indicators of air quality. Significant improvements in water indicators seem likely as a result of the work being organized by the UNEP in preparation for its proposed *Global Environmental Outlook* report.

Another area requiring more work is that of institutional indicators. The CSD is already taking some steps by following through with the examination of laws having to do with sustainable development. The monitoring of the implementation of international legal instruments by contracting parties is one possible indicator. Each country concerned in the Convention on Biodiversity could, for instance, be monitored for the degree to which it has established a system of protected areas, developed conservation facilities, or enacted a national strategy.

While it may be some years before most countries can actually report data on such indicators, revision of the sustainability matrix and recompilation of indicators based on available data is likely to become a continuing process, as it is for socioeconomic indicators. Above all, where there is a gap in the matrix, there is a requirement for fresh thinking on policy-relevant indicators related to these themes and the identification of the minimal data needed for optimally inaccurate indicators. In cooperation with the community of practitioners on indicator development, the World Bank intends to move this work forward.

The indicators presented here are first estimates designed to elicit better ideas. We are releasing summary results at this stage to invite comments about other compilation procedures that might yield significantly different results. It should be emphasized that the sustainability matrix presented here focuses on what can be done without major changes in data collection activities. It is in this sense an adaptation of the OECD's near-term work program for environmental indicators to the broader subject of sustainable development—with special attention to developing rather than advanced countries. As a preliminary stock-taking exercise, the indicators in the matrix were evaluated relative to the availability of necessary basic data in central data bases available to the World Bank for a fair number of developing countries.

The objective is to identify where crude, national-level indicators could be compiled quickly (those with no qualifiers to the indicator named in the matrix). Where compilation is not immediately possible, it is to identify the major decision points for progress. For example, entries preceded by an asterisk are uncertain in ways that are not immediately apparent. They are composites whose weights, or embedded valuation rules, can be debated and may or may not influence the trends in the proposed index. Components that are important for one country, furthermore, may be irrelevant for another.

Accepted procedures for testing and reporting on alternative weighting schemes (such as sensitivity analysis) will probably have to be devised before consensus emerges on actual compilation of composite indicators. Entries followed by "X" are ones for which experts have proposed sources and methods but for which no actual data sets have been compiled. Procedures designed to test alternative composites might also provide guidelines for deciding practical next steps for compiling some international comparisons of these prospective indicators. Entries followed by "❖" are supported by data compiled internationally by one or more organizations (such as Bank-staff estimates of subsoil assets as a percentage of wealth). Dissemination of the results in sufficient detail to allow others to experiment with alternative weightings, and so on, could expedite refinement and consensus. Entries flagged with "?" are still so undefined as to be medium- rather than near-term candidates for the matrix and are included mainly in hopes of obtaining concrete examples of how such indicators could be, or have been, compiled. And "missing" entries (· · · · · ·) indicate where even more basic thinking about indicators is needed.

Reference Values

Perhaps the most important change in thinking about indicators in recent years has been the distinction that has been made between descriptive and performance indicators. Traditional approaches to the development of environmental indicators were concerned almost exclusively with describing the state of the environment (for instance, by giving a summary measure of the ambient concentrations of pollutants). Performance indicators, on the other hand, aim to measure the distance from ambient conditions to a stated policy goal or technical threshold.

For example, the percentage amount by which the concentration of suspended particulates exceeds a WHO guideline for unsafe levels would be a performance indicator, while reports on the concentrations per se would be descriptive indicators. Performance indicators are key to establishing the policy relevance of an indicator set. Indicators presented in this edition of *Monitoring Environmental Progress* are, therefore, either explicitly or implicitly performance indicators. Focusing on performance indicators identifies the subset of conceptually valid descriptive indicators that are applicable to decisionmaking at a given time and place. It also acknowledges that technical targets or policy goals need to be specified and stresses that the precision of performance indicators depends as much on the clarity of these targets and goals as on the quality of monitoring and evaluation techniques.

The work done by the Canadian Institute of Chartered Accountants in integrating performance indicators with policies and business enterprise issues has been particularly helpful.

Analytical and Policy Uses

Trial approaches of the type presented in this publication can flag key unknowns for decisionmakers. Without this type of focus, the costs of improving environmentally sustainable development indicators would be prohibitive. At the same time the international community at large should have a voice in setting priorities for further data work and deciding when intermediate solutions may suffice.

The present report aims to promote a participatory process in determining how environmentally sustainable development indicators should be compiled and used. The focus is on the gray area where compilation and use meet, rather than on the in-depth examination of compilation methods. While this report was written by Bank staff, it is hoped that contributions from experts outside the Bank will appear in future editions.

The next important step will be to devise an open, well-distributed, and highly participatory knowledge base regarding environmentally sustainable development. Only then are we likely to reach consensus about the need to collect basic data now to research the complex interactions between humans and their environment.

Progress in this would be accelerated if adequate attention were given to reaching agreement on processes for synthesizing details into progressively more aggregated measures. Some entries of the sustainability matrix may already be more summary than some users would want, and most are more summary than compilers are used to reporting. On the other hand, there are upwards of 100 indicators in the near-term matrix, which is too many for most analysts to grasp, even if there were no need to disaggregate some entries at present, because compilers and users have not yet agreed on protocols for such highly synthesized indicators.

For the next few years organizations and individuals will position themselves at different levels of the abstraction-specificity staircase suggested by the matrix's hierarchical approach to issues. For obvious reasons, the above-mentioned methodology sheets will tend to be more detailed than entries in the sustainability matrix. Others, notably the Scientific Committee on Problems of the Environment (SCOPE), will promote indicators as near to the top of the staircase as possible. (SCOPE has already proposed four indicators to cover the driving force column of the environmental segment of the matrix.) Concrete proposals have been made for a resource-depletion index to monitor sources and a pollution index to gauge sinks. Preliminary thinking has been outlined for an ecosystem risk index and an index of environmental impact on human health.

Technical Notes for Tables and Figures

Figure 1.2. Current and forecast demand data are from Narendra Sharma and others, *Managing the World's Forests.*[3] The estimate of sustainable world production is based on the estimated global average increment figure of 1.1 cubic meters per hectare per year given in Alexander S. Mather, *Global Forest Resources,*[4] and the estimated world forest area of 4,038 million hectares given in World Resources Institute, *World Resources 1994–95.*[5] Although rigorous confidence limits are not available for either estimate, a nonscalar band estimate was used in the figure to represent an estimated sustainable yield of 4,440 million cubic meters per year, thus providing a visual representation of the uncertainty associated with the available global-level data. The increasing spread with time illustrates the greater uncertainty associated with longer-term projections.

Figures 1.3 and 1.4. Regional forest coverage was aggregated from individual national data, which were compiled from several sources. Data for most tropical countries come from Food and Agriculture Organization, *A Forest Resources Assessment.*[6] Other sources are Food and Agriculture Organization, *Production Annual Yearbook,*[7] World Resources Institute, *World Resources 1994–95,*[8] World Bank, *World Development Report 1994,*[9] and World Bank staff estimates. For some countries extrapolations were made from areas with similar ecological and land use characteristics. Forest cover data for each country, shown in Figure 1.4, were constructed based on the ratio of the current area of forest to the estimated total land area. In adopting this approach, it was recognized that where the environment is not conducive to forest development, the proportion of forest cover would be low even in the complete absence of human activity. Figure 1.4 would give a more complete picture if it were based on the ratio of actual forest area to potential forest area, but such data were not available at the time of writing. While our approach may give a misleading picture of the forest situation in countries (such as Greenland) that have naturally low levels of forest cover, the extent of forest cover remaining in a country does indicate where forest resources are scarce, regardless of the extent of the original forest area. The analysis gives a useful first-order indication of priorities for conservation management efforts, particularly for countries with low levels of forest cover and high rates of forest loss.

Figures 4.1–4.5. The International Trade Division of the International Economics Department of the Bank compiled the data for metals and minerals that appear in these tables from a number of sources, including the UNCTAD Secretariat, the UN Trade Analysis and Reporting System (TARS), *World Metal Statistics*, and *Metallstatistic*, an annual publication of Metallgesellschaft Aktiengesellschaft. Income and population estimates are from World Bank sources.

Table 5.1. Excess carbon dioxide emissions are calculated from B. Larsen, "World Fossil Fuel Subsidies and Global Carbon Emissions,"[10] using fossil fuel emissions data given in an update by the Carbon Dioxide Information and Analysis Center (CDIAC) of the data in G. Marland and others, *Estimates of CO_2 Emissions from Fossil Fuel Burning and Cement Manufacturing.*[11] The methods used are described in World Resources Institute, *World Resources 1994–95.*[12]

Figure 5.1. In B. Larsen, "World Fossil Fuel Subsidies and Global Carbon Emissions,"[13] fuel subsidies are distinguished by fuel type and consuming sector, permitting the calculation of "net" fossil fuel subsidies, that is, subsidies on fuels used for all purposes except the generation of electricity. Without this important distinction, there is a risk of double-counting subsidies in the case of electricity generated from fossil fuels.

Figure 5.2. Electricity subsidies are calculated as the difference between the long-run marginal cost of generation (as estimated in World Bank sectoral studies for specific countries) and the average revenue per kilowatt hour, as reported in the source cited in the figure. This implicit subsidy calculation subsumes both direct subsidies to consumers and any subsidies on inputs of capital and fossil fuels.

Table 6.1 and Figure 6.1. Incremental emissions for 1986–91 were calculated by fitting a linear trend to CDIAC emissions data. Where the trend was insignificant, the increment was set to zero. This process was repeated for both individual country data and world total emissions.

Table 6.2 and Figures 6.1, 6.3, 6.4, and 6.5. The Carbon Dioxide Information and Analysis Center (CDIAC) releases annual updates of the carbon emissions data appearing in G. Marland and others, *Estimates of CO_2 Emissions from Fossil Fuel Burning and Cement Manufacturing.*[14] These data were combined with standard World Bank data on population and gross national product contained in the Bank Economic and Social Database (BESD).

Figure 6.3. The map groups countries according to the ratio of country-level incremental emissions to world incremental emissions (which were on the order of 83 million tons per year, representing a growth rate of about 1.5 percent per year). Countries with decreasing emissions have negative ratios.

Figure 6.6. The Kuznets-type curve was derived by fitting a quadratic curve of carbon emissions per dollar of gross national product (GNP) averaged for 1989–91 to the logarithm (base 10) of average per capita income for this same period. The regression statistics are as shown in the following table, for regression equation:

$$y_i = ax_i^2 + bx_i + c_i + e_i.$$

In this equation y measures CO_2/\$GNP, while x is $\log_{10}$(\$GNP/capita). There are 126 degrees of freedom.

Regression statistics

a	*b*	*c*	r^2	*F*
–0.00013	0.000846	0.00113	0.134	9.752
(-4.265)	(4.355)			

Note: Numbers in parentheses are t-statistics.

While the r^2 is low, as is typical for cross-section data, the coefficients are highly significant. We can conclude from the regression equation that carbon emissions peak at a GNP of about $1,800 per capita.

Figures 7.3c and 7.3d. Standard national accounting defines saving as a residual, production minus consumption (C), both public and private. The notion of genuine saving is given by the following basic accounting identities:

$$S_g = \text{GNP} - C - D_r - D_n = I - \text{NFB} - D_r - D_n.$$

Here D_r is depreciation of fixed capital, D_n is degradation and depletion of natural capital, I is gross investment, and NFB is net foreign borrowing. It is the second version of these identities that is plotted in Figures 7.3c and 7.3d. Note that this second version can be interpreted as explaining how produced assets are financed: Investment is financed by the sum of net foreign borrowing, a depreciation allowance, a depletion allowance (broadly defined), and genuine saving. Negative genuine saving is an indication that the net asset position of the country is deteriorating.

Figure 8.3. The produced assets component was compiled from information provided in Vikram Nehru and Ashok Dhareshwar, "New Estimates of Total Factor Productivity Growth for Developing and Industrial

Countries."[15] See also Vikram Nehru and Ashok Dhareshwar, "A New Database on Physical Capital Stock: Sources, Methodology, and Results."[16]

Notes

1. United Nations Statistical Division, *Framework for the Development of Environmental Statistics* (New York: United Nations, 1984).

2. United Nations Commission on Environment and Development, *Agenda 21* (New York: UNCED, 1992).

3. Narendra Sharma and others, *Managing the World's Forests* (Dubuque, Iowa: Kendall/Hunt Publishing Company, 1992), p. 29.

4. Alexander S. Mather, *Global Forest Resources* (London: Belhaven Press, 1990), p. 25.

5. World Resources Institute, *World Resources 1994-95: A Guide to the Global Environment* (New York: Oxford University Press, 1994), p. 135.

6. Food and Agriculture Organization, *A Forest Resources Assessment (Tropical Countries) 1990* (Geneva: FAO, 1993).

7. Food and Agriculture Organization, *Production Annual Yearbook* (New York: FAO, various issues).

8. World Resources Institute, *World Resources 1994–95*, table 19.1.

9. World Bank, *World Development Report 1994* (New York: Oxford University Press, 1994).

10. B. Larsen, "World Fossil Fuel Subsidies and Global Carbon Emissions in a Model with Interfuel Substitution." Policy Research Working Paper no. 1256. Policy Research Department, World Bank, Washington, D.C., 1994.

11. G. Marland and others, *Estimates of CO_2 Emissions from Fossil Fuel Burning and Cement Manufacturing Based on the United Nations Energy Statistics and the U.S. Bureau of Mines Cement Manufacturing Data*. ORNL/CDIAC-25, NDP-030 (Oak Ridge, Tenn.: Carbon Dioxide Information and Analysis Center, 1989).

12. World Resources Institute, *World Resources 1994–95.*

13. B. Larsen, "World Fossil Fuel Subsidies and Global Carbon Emissions."

14. G. Marland and others, *Estimates of CO_2 Emissions.*

15. Vikram Nehru and Ashok Dhareshwar, "New Estimates of Total Factor Productivity Growth for Developing and Industrial Countries." Policy Research Working Paper no. 1313. International Economics Department, World Bank, Washington, D.C., June 1994.

16. Vikram Nehru and Ashok Dhareshwar, "A New Database on Physical Capital Stock: Sources, Methodology, and Results," *Revista de Análisis Económico* 8 (June 1993): 37–59.

Distributors of World Bank Publications

ARGENTINA
Carlos Hirsch, SRL
Galeria Guemes
Florida 165, 4th Floor-Ofc. 453/465
1333 Buenos Aires

Oficina del Libro Internacional
Alberti 40
1082 Buenos Aires

AUSTRALIA, PAPUA NEW GUINEA, FIJI, SOLOMON ISLANDS, VANUATU, AND WESTERN SAMOA
D.A. Information Services
648 Whitehorse Road
Mitcham 3132
Victoria

AUSTRIA
Gerold and Co.
Graben 31
A-1011 Wien

BANGLADESH
Micro Industries Development Assistance Society (MIDAS)
House 5, Road 16
Dhanmondi R/Area
Dhaka 1209

BELGIUM
Jean De Lannoy
Av. du Roi 202
1060 Brussels

BRAZIL
Publicacoes Tecnicas Internacionais Ltda.
Rua Peixoto Gomide, 209
01409 Sao Paulo, SP

CANADA
Le Diffuseur
151A Boul. de Mortagne
Boucherville, Québec
J4B 5E6

Renouf Publishing Co.
1294 Algoma Road
Ottawa, Ontario K1B 3W8

CHINA
China Financial & Economic Publishing House
8, Da Fo Si Dong Jie
Beijing

COLOMBIA
Infoenlace Ltda.
Apartado Aereo 34270
Bogota D.E.

COSTA RICA, BELIZE, GUATE-MALA, HONDURAS, NICARAGUA, PANAMA
Chispas Bookstore
75 Meters al Norte del Hotel Balmoral en calle 7
San Jose

COTE D'IVOIRE
Centre d'Edition et de Diffusion Africaines (CEDA)
04 B.P. 541
Abidjan 04 Plateau

CYPRUS
Center of Applied Research
Cyprus College
6, Diogenes Street, Engomi
P.O. Box 2006
Nicosia

CZECH REPUBLIC
National Information Center
P.O. Box 668
CS-113 57 Prague 1

DENMARK
SamfundsLitteratur
Rosenoerns Allé 11
DK-1970 Frederiksberg C

EGYPT, ARAB REPUBLIC OF
Al Ahram
Al Galaa Street
Cairo

The Middle East Observer
41, Sherif Street
Cairo

FINLAND
Akateeminen Kirjakauppa
P.O. Box 23
FIN-00371 Helsinki

FRANCE
World Bank Publications
66, avenue d'Iéna
75116 Paris

GERMANY
UNO-Verlag
Poppelsdorfer Allee 55
53115 Bonn

GREECE
Papasotiriou S.A.
35, Stournara Str.
106 82 Athens

HONG KONG, MACAO
Asia 2000 Ltd.
46-48 Wyndham Street
Winning Centre
7th Floor
Central Hong Kong

HUNGARY
Foundation for Market Economy
Dombovari Ut 17-19
H-1117 Budapest

INDIA
Allied Publishers Private Ltd.
751 Mount Road
Madras - 600 002

INDONESIA
Pt. Indira Limited
Jalan Borobudur 20
P.O. Box 181
Jakarta 10320

IRAN
Kowkab Publishers
P.O. Box 19575-511
Tehran

IRELAND
Government Supplies Agency
4-5 Harcourt Road
Dublin 2

ISRAEL
Yozmot Literature Ltd.
P.O. Box 56055
Tel Aviv 61560

R.O.Y. International
P.O. Box 13056
Tel Aviv 61130

Palestinian Authority/Middle East
Index Information Services
P.O.B. 19502 Jerusalem

ITALY
Licosa Commissionaria Sansoni SPA
Via Duca Di Calabria, 1/1
Casella Postale 552
50125 Firenze

JAMAICA
Ian Randle Publishers Ltd.
206 Old Hope Road
Kingston 6

JAPAN
Eastern Book Service
Hongo 3-Chome, Bunkyo-ku 113
Tokyo

KENYA
Africa Book Service (E.A.) Ltd.
Quaran House, Mfangano St.
P.O. Box 45245
Nairobi

KOREA, REPUBLIC OF
Daejon Trading Co. Ltd.
P.O. Box 34
Yeoeida
Seoul

MALAYSIA
University of Malaya Cooperative Bookshop, Limited
P.O. Box 1127, Jalan Pantai Baru
59700 Kuala Lumpur

MEXICO
INFOTEC
Apartado Postal 22-860
14060 Tlalpan, Mexico D.F.

NETHERLANDS
De Lindeboom/InOr-Publikaties
P.O. Box 202
7480 AE Haaksbergen

NEW ZEALAND
EBSCO NZ Ltd.
Private Mail Bag 99914
New Market
Auckland

NIGERIA
University Press Limited
Three Crowns Building Jericho
Private Mail Bag 5095
Ibadan

NORWAY
Narvesen Information Center
Book Department
P.O. Box 6125 Etterstad
N-0602 Oslo 6

PAKISTAN
Mirza Book Agency
65, Shahrah-e-Quaid-e-Azam
P.O. Box No. 729
Lahore 54000

Oxford University Press
5 Bangalore Town
Sharae Faisal
P.O. Box 13033
Karachi-75350

PERU
Editorial Desarrollo SA
Apartado 3824
Lima 1

PHILIPPINES
International Book Center
Suite 720, Cityland 10
Condominium Tower 2
Ayala Avenue, H.V. dela Costa Extension
Makati, Metro Manila

POLAND
International Publishing Service
Ul. Piekna 31/37
00-577 Warszawa

PORTUGAL
Livraria Portugal
Rua Do Carmo 70-74
1200 Lisbon

SAUDI ARABIA, QATAR
Jarir Book Store
P.O. Box 3196
Riyadh 11471

SINGAPORE, TAIWAN
Gower Asia Pacific Pte Ltd.
Golden Wheel Building
41, Kallang Pudding, #04-03
Singapore 1334

SLOVAK REPUBLIC
Slovart G.T.G. Ltd.
Krupinska 4
P.O. Box 152
852 99 Bratislava 5

SOUTH AFRICA, BOTSWANA
Oxford University Press
Southern Africa
P.O. Box 1141
Cape Town 8000

SPAIN
Mundi-Prensa Libros, S.A.
Castello 37
28001 Madrid

Librería Internacional AEDOS
Consell de Cent, 391
08009 Barcelona

SRI LANKA & THE MALDIVES
Lake House Bookshop
P.O. Box 244
100, Sir Chittampalam A. Gardiner Mawatha
Colombo 2

SWEDEN
Fritzes Customer Service
Regeringsgatan 12
S-106 47 Stockholm

Wennergren-Williams AB
P.O. Box 1305
S-171 25 Solna

SWITZERLAND
Librairie Payot
Case postale 3212
CH 1002 Lausanne

Van Diermen Editions Techniques
P.O. Box 465
CH 1211 Geneva 19

TANZANIA
Oxford University Press
Maktaba Street
P.O. Box 5299
Dar es-Salaam

THAILAND
Central Books Distribution Co. Ltd.
306 Silom Road
Bangkok

TRINIDAD & TOBAGO, JAMAICA
Systematics Studies Unit
#9 Watts Street
Curepe
Trinidad, West Indies

UGANDA
Gustro Ltd.
1st Floor, Room 4, Geogiadis Chambers
P.O. Box 9997
Plot (69) Kampala Road
Kampala

UNITED KINGDOM
Microinfo Ltd.
P.O. Box 3
Alton, Hampshire GU34 2PG
England

ZAMBIA
University Bookshop
Great East Road Campus
P.O. Box 32379
Lusaka

ZIMBABWE
Longman Zimbabwe (Pte.) Ltd.
Tourle Road, Ardbennie
P.O. Box ST 125

THE WORLD BANK
A partner in strengthening economies
and expanding markets
to improve the quality of life
for people everywhere,
especially the poorest

Headquarters
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.
Telephone: (202) 477-1234
Facsimile: (202) 477-6391
Telex: MCI 64145 WORLDBANK
MCI 248423 WORLDBANK
Cable Address: INTBAFRAD
WASHINGTONDC
World Wide Web: http://www.worldbank.org
E-mail: books@worldbank.org

European Office
66, avenue d'Iéna
75116 Paris, France
Telephone: (1) 40.69.30.00
Facsimile: (1) 40.69.30.66
Telex: 640651

Tokyo Office
Kokusai Building
1-1, Marunouchi 3-chome
Chiyoda-ku, Tokyo 100, Japan
Telephone: (3) 3214-5001
Facsimile: (3) 3214-3657
Telex: 26838

ISBN