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Integrated Environmental-Economic Accounting, Natural Resource Accounts, and Natural Resource Management in Africa

by

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List of Acronyms

CBA	Cost-Benefit Analysis
CBO	Congressional Budget Office
CGE	Computable General Equilibrium
EDP	Environmentally Adjusted Domestic Product
EEC	European Economic Commission
GDP	Gross Domestic Product
I-O	Input-Output
MEW	Measurement of Economic Welfare
NAMEA	National Accounting Matric including Environmental Accounts
NCSA	National Conservation Strategy Agency (Botswana)
NDP	Net Domestic Product
NEAP	National Environmental Action Plan
NRA	Natural Resource Accounts
OECD	Organization for Economic Co-operation and Development
SEEA	System of Environmental and Economic Accounting
SAM	Social Accounting Matrix
SNA	System of National Accounts
TIP	Trade and Investment Program
U.N.	United Nations

Executive Summary

A wide consensus exists that societies need to be concerned not only with income generation and distribution but also with the depletion of resources and environmental degradation. For this reason, the international community of national accountants, represented by the United Nations (U.N.) Statistical Office, has added Natural Resource Accounts (NRA) to the System of National Accounts (SNA), the framework for the collection of economic information recommended for all countries.

Data used to estimate Gross Domestic Product (GDP) are collected at different levels of detail and with different degrees of quality control in each country. Some countries collect these data only to report them to the international community, while others use them in various areas of public and private decision-making. The same is true for NRA. The question is not whether to develop NRA, but what priority should be accorded to them in a particular country and how to proceed.

NRA can be used for three purposes: 1) to construct an aggregate indicator of sustainable development, 2) to monitor the state of the environment and economy, or 3) for policy analysis and planning. This report describes two overlapping but different approaches to constructing NRA: summary NRA and management-oriented NRA. The former is a short-cut method to estimate sustainable income (Environmentally Adjusted Domestic Product [EDP]); the latter can be used for all three purposes but is especially oriented toward policy analysis.

The summary NRA approach estimates EDP by revising Net Domestic Product (NDP) to include a cost for the net deterioration of natural capital. This is accomplished by estimating a total monetary value for all natural resources use and environmental degradation and then subtracting this number from NDP to obtain EDP. While it is appealing to have a single-valued indicator of sustainability, EDP has a number of weaknesses. First, the valuation techniques for many nonmarketed natural resources and environmental damage are problematic. Some argue that the problem is not just technical or methodological, but that meaningful valuation of some aspects of natural capital cannot be based on economic criteria alone. While some valuation problems might be solved through agreement about techniques, a fundamental valuation problem remains. The imputed costs of environmental degradation cannot simply be added to conventional NDP because, if the hypothetical costs had actually been incurred, all transactions in the economy would have been different. Consequently, some argue that calculating EDP is not an accounting exercise but a modeling challenge. Second, measurement of EDP provides no guidance about how to achieve sustainable development; this approach to NRA does not furnish the information required to design and evaluate development strategies. Summary NRA have played an important role in NRA's early stages of development by focusing on the importance of environmental degradation, but this limited approach to NRA will not suffice in the future.

The United Nations recommends management-oriented NRA. Data are constructed initially in physical units as stock and flow "satellite accounts" to the SNA. The flow accounts

are similar in structure to the input-output (I-O) table of the national accounts and record the extraction and use in production and by consumers of natural resources and the discharge of waste materials associated with each sector's activities, including households. Valuation techniques can be applied to estimate monetary values for the stocks and flows and to calculate EDP. This approach has been used in Norway, the first country to begin compiling NRA, and subsequently in France, Mexico, Philippines, Netherlands, and Botswana (the only African country to have attempted NRA). Indonesia, Sweden, and Thailand have started or are planning to construct management-oriented NRA.

Both macro- and sectoral-level policies can be monitored and evaluated for their economic and environmental impacts on the basis of these NRA. Many potential policy applications of NRA have been suggested in the U.N. handbook (United Nations 1992), including analysis of the distributional effects of natural resources policies or the link between trade and natural resources policies. Examples of applications include calculating the distributional effects of a tax on emissions of sulfur oxides (Norway), the economywide costs and benefits of alternative means to reduce pollution and the environmental and economic effects of alternative land-use policies (Philippines), and the economywide effect of a carbon tax and of policies to reduce water pollution resulting from agriculture (Netherlands).

Experience with NRA in different countries has shown that their effective use poses challenges at various levels, especially the institutional level. Both construction and use of NRA require cooperation across ministries and professional disciplines. Even for monitoring purposes, these data require interpretation through the use of physical standards or monetary valuation techniques. The more ambitious use of NRA in support of sustainable development requires identifying possible development strategies that will change the state of the economy and the environment and a model to evaluate these strategies. Therefore, while management-oriented NRA offer much more to the policy analyst, their effective use is also a more ambitious undertaking than constructing summary NRA.

The authors' principal recommendation about NRA in Africa is that it is useful to begin this work in some countries at this time, mainly in those where an effective capability for policy analysis and planning are already or in the process of being established (NRA can be incorporated into this capability) and where the data are adequate to address the policy questions. In many countries, the data required for constructing NRA already exist, albeit dispersed among several ministries; the challenge of compiling data from different sources is not as costly as primary data collection. Due to the cost of constructing and using NRA effectively, natural resource accounting may not represent the best use of human and financial resources in other African countries at this time. Since the NRA framework includes a range of natural resource variables and environmental impacts across multiple economic sectors, NRA are most useful to address development alternatives that require coordination among different sectors competing for scarce resources, such as livestock, agriculture, forestry, and wildlife management. It is not necessary to construct NRA to address problems concerning a single issue or single sector.

1. Introduction

National income and product accounts record detailed transactions among economic sectors, such as agriculture, minerals, manufacturing, and services, as well as purchase of goods and services for household and government use and for trade and investment in a given year. National accounts serve two major purposes: 1) analysis (they provide input to models for economic evaluations) and 2) monitoring (they furnish such summary measures as GDP (see Box A) that indicate an economy's performance. One of these summary measures, NDP, has been interpreted as sustainable income or the level of income that could be produced indefinitely with a given stock of capital in the absence of structural change in the economy. NDP is defined as GDP minus the investment required to maintain the stock of capital.

However, NDP overestimates sustainable income because natural capital is needed for production but investment in its maintenance is not accounted for in the national accounts. In fact, much use of natural capital is omitted entirely from the accounts because it is not exchanged through market transactions. NRA are designed to remedy this omission by assembling information about the stocks and flows of natural capital that could be used for monitoring the state of the environment and the economy and for integrated environmental and economic analysis. While there is wide support for the collection of these types of data, few NRA have been compiled, let alone maintained on a regular basis, by national statistical offices; the use of NRA for policy analysis is even more limited. The major efforts are identified in Table 1.

Unlike national income accounts in which the same information in the same format is collected for all countries, NRA vary in terms of the conventions they use, level of detail and empirical content, and the environmental issues addressed. The United Nations' recently published handbook on NRA as a set of satellite accounts to the SNA is a major step toward standardization, though much work remains (United Nations 1993).

NRA have been used for three purposes: 1) constructing an indicator of sustainable income, 2) monitoring the state of the environment and economy, and 3) policy analysis and strategic planning. The two major categories of NRA are summary NRA and management-oriented NRA. The former is a short-cut method to estimate sustainable income while the latter, used for all three purposes, is especially oriented toward analysis.

Box A

Gross Domestic Product represents the total monetary value of domestically produced goods and services in a given year for final use in private consumption, government expenditures, investment, or trade. GDP is also equal to the total value of payments to all domestic factors of production. GDP differs from Gross National Product in that the latter includes net factor income earned abroad.

Table 1. Countries that have constructed or are planning to construct natural resource accounts

Country[a]	Countries with Accounts Updated Regularly	Objective[b]
France	National Institute of Statistics and Economic Studies and Ministry of the Environment (since 1986)	Management
Netherlands	National Accounts Research Division, Central Bureau of Statistics	Management
Norway	Central Bureau of Statistics and Ministry of Environment (since 1978)	Management
	Countries with Accounts Created but Not Maintained Regularly	
Botswana	Central Statistical Office, Ministry of Finance and Development	Management
Costa Rica	See Tropical Science Center (1991)	EDP
Japan	Economic Council of Japan	EDP
Mexico	See van Tongeren, Schweinfest, and Lutz (1991)	Management/EDP
Papua New Guinea	See Bartelmus, Lutz, and Schweinfest (1992)	EDP
	Countries Where Work Has Begun	
Canada	Statistics Canada	Management/EDP
Germany	Federal Statistics Office	EDP
Indonesia	Central Statistics Office and United Nations	Management/EDP
Philippines	Department of Environment and Natural Resources	Management/EDP
Sweden	Commission for Environmental Accounting, Ministry of Finance	Management
Thailand	Central Statistics Office and United Nations	Management/EDP
United States	Department of Commerce and Environmental Protection Agency	EDP

[a] This list includes countries that have constructed or are planning to construct NRA as part of their national accounting activities. Not included are NRA that have been constructed by other agencies, institutions, or individuals or for smaller geographic regions or parts of the national economy. Virtually all published literature on NRA is based on the countries and approaches indicated in this table.

[b] Management = management-oriented NRA; EDP = environmentally adjusted domestic product or summary NRA.

The objective of summary NRA, exemplified by the widely known work of Repetto et al. (1989) in Indonesia and Costa Rica, is to construct a better indicator of sustainable income by revising NDP (or sometimes GDP) to include a cost for the deterioration (or improvement) of natural capital. This is accomplished by estimating a total monetary value for all uses of natural resources and environmental degradation and subtracting this number from NDP to obtain EDP, commonly known as "green GDP." Sustainable development requires that EDP not decrease over time.

The summary NRA approach achieves tremendous simplicity by providing a single, quantitative measure for sustainable development. However, its simplicity is achieved at a cost. First, the valuation techniques for many nonmarketed natural resources and environmental damage are problematic. (Some argue that the problem is not just technical or methodological, but that meaningful valuation of some aspects of natural capital cannot be based on economic criteria alone [Goodwin 1991, 44; Sagoff 1988, 92-95; Stirling 1992].) Second, EDP provides no guidance about how to achieve sustainable development; this approach to NRA does not furnish the information required to design and evaluate development strategies. Nonetheless, summary NRA call attention to the importance of environmental degradation.

Management-oriented NRA, like national income and product accounts, are designed to provide data for use in analytical models, as well as for summary measures. These NRA are constructed initially in physical units as stock and flow satellite accounts that supplement the national accounts (see Box B). The flow accounts are structured similarly to the interindustry portion or I-O tables of the national accounts. They record the extraction and the use in production and by consumers of natural resources and the discharge of waste materials associated with each sector's activities, including those of households. Both macro- and sectoral-level policies can be described, monitored, and evaluated for their economic and environmental impact on the basis of these NRA. This approach has been used in Norway, the first country to begin compiling NRA, and subsequently in France, Mexico, Philippines, Netherlands, and Botswana (the only African country to thus far attempt NRA). Management-oriented NRA, the approach the United Nations recommends, has been proposed for Thailand and Sweden.

Box B

I-O tables provide a set of accounts that record transactions (purchases and deliveries) among industries in a given year, the sectoral composition of GDP, and the distribution of value added among various industries. The tables are in the form of a matrix and resemble a double-entry bookkeeping system: each row represents the deliveries from one industry to all industries, and each column represents one industry's purchases from all industries. Wages, profits, rents, taxes, and subsidies in each industry are also distinguished. Consequently, I-O tables show the industry-level detail for both the value added and the final deliveries that comprise a nation's GDP. More than 100 countries regularly compile I-O tables, which are a part of the SNA.

Aggregate, economywide physical indicators can also be tabulated for each resource from the detailed sectoral information (e.g., the volume and rate of deforestation or the solid waste that each sector generates). These measures, with appropriate standards for interpretation, are used with conventional measures of economic performance, like NDP, to assess sustainability much as the unemployment rate, inflation rate, and measures of income distribution are used with GDP to assess economic performance. It is also possible to estimate a monetary value for these indicators (the valuation problem already mentioned applies here) and calculate EDP from these NRA. The United Nations has proposed such an approach and implemented it in Mexico. The methods for estimating these values are acknowledged as experimental. Since the United Nations does not recommend a single valuation method, EDP will not be unique. Many proponents of management-oriented NRA consider valuation of some nonmarketed resources useful to address specific policy questions but inappropriate for calculating a unique EDP because of the valuation problems and because sustainability cannot be meaningfully summarized in a single "bottom-line" number.

While the satellite accounts can be used for many purposes, they describe the state of the environment only in a given year. Even for monitoring purposes, these data require interpretation through the use of physical standards or monetary valuation techniques. The more ambitious use of NRA in support of sustainable development requires the identification of possible development strategies that will change the state of the economy and the environment and a model to evaluate these strategies. Therefore, while management-oriented NRA offer much to the policy analyst, their effective use is a more complex undertaking than is the construction of summary NRA.

The U.N. handbook on NRA represents the international consensus that NRA are an important tool for integrating environmental and economic analysis (van Tongeren 1993, personal communication). The handbook recommends constructing management-oriented NRA for use in calculating EDP, for monitoring the state of the environment and economy, and for analysis. Nonetheless, the handbook provides no definitive guidance on valuation of the NRA, suggesting the calculation of several levels of EDP, which include different types of natural resources and special studies not directly integrated with the national accounts. There has been considerable discussion in the literature about conceptual issues related to NRA but comparatively little experience collecting and using the data. Additional progress with NRA will require experience in constructing the accounts and applying them to environmental and economic problems.

The authors' principal recommendation about NRA in Africa is that it is useful to begin this work in some countries at this time, mainly those where an effective capability for policy analysis and planning are already or in the process of being established (constructing NRA can be part of the process of building this capability) and where data are adequate to address policy questions. In many countries, the data required for constructing NRA already exist, albeit dispersed among several ministries; the challenge of compiling data from different sources is not as costly as primary data collection. Due to the cost of constructing and using NRA effectively, natural resource accounting may not represent the best use of human and financial resources in other African countries.

In countries proposing to construct NRA, management-oriented NRA, which the United Nations recommends, rather than the more limited summary NRA, should be constructed so that the effort yields data that can be used to design and evaluate responses to problems that arise in the course of development. Practical implementation at this early stage of NRA development requires a sequential approach: the scope of the NRA and their application to specific problems would be extended gradually based on feedback from potential users to ensure their policy relevance. A careful setting of priorities about the NRA is required.

Initially, accounts should be constructed in physical units as the United Nations recommends. Experiments with valuation appropriate to specific policy questions can then be carried out. The challenge of sustainable development, especially in developing countries, requires an understanding of the relations among different parts of the economy and the environment; these relations cannot be represented in a single indicator.

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2. Summary Natural Resource Accounts

The primary objective of summary NRA is to provide a better indicator of sustainable income by deducting from NDP a charge for the net deterioration of natural capital. The resulting measure, EDP, is generally lower than NDP. (If there are increases in the stock of natural capital, EDP could be higher.) This approach is based on the argument that natural capital is a collection of productive assets and that charges for depletion and degradation of these assets should be included in the national accounts just like the charges for produced capital. Natural capital (not a well-defined concept) in practice includes natural and environmental resources that are of obvious importance as sources or sinks for economic activities. EDP is calculated by deducting from NDP one or more of the following:

- defensive expenditures; i.e., spending on pollution prevention or clean up
- value of depletion and degradation of marketed natural resources
- imputed value of depletion and degradation of nonmarketed natural resources

Of the countries listed in Table 1, Germany and the United States record only defensive expenditures while other countries use varying methods to estimate depletion or degradation of selected natural resources, including both marketed resources like oil and lumber and nonmarketed material and environmental resources like soil (e.g., Costa Rica, Indonesia, Mexico, and Papua New Guinea). The accounts that the Economic Council of Japan created in the early 1970s included defensive expenditures and the imputed value of nonmarketed natural resources as part of a larger attempt to construct measurement of economic welfare (MEW), which includes charges for many other activities in addition to environmental degradation (Nordhaus and Tobin 1973). Researchers in Japan updated this work in the 1980s (Uno 1990 and 1991).

The four summary NRA most widely discussed in the literature are described in Table 2. These NRA vary in terms of coverage of natural resources and the magnitude of the estimated value of damage to the environment. Since NRA are new, there is no standard way of reporting these adjustments; some are reported as a percent of GDP, others in terms of NDP. In Mexico and Papua New Guinea, for example, a range of values for EDP was estimated by varying the resources included and the valuation techniques used. In all cases, the estimated depletion of natural capital is significant (3.7-9.0 percent of GDP).

Conceptually and practically, the usefulness of EDP depends on whether NDP, partially adjusted for the costs of maintaining or damaging the environment, can be a useful measure of sustainable income. Treating natural capital like produced capital in the national accounts first requires establishment of boundaries to distinguish that portion of the natural world to be included in the national accounts and its quantification in terms of physical stocks and flows. Second, since EDP can be calculated only through imputations of value to those stocks and flows, EDP requires coherent methods for attributing a monetary value to natural resources with no market prices. Finally, the use of this measure of sustainable income needs to be examined.

Table 2. Estimates of EDP from four major summary natural resource accounts

Country and Resources	EDP and Valuation Method Used
Costa Rica	Average 5% lower than GDP in 1970-1980
Forests	Net price for harvested timber
Soil	Avoidance cost of fertilizer to provide lost nutrients
Fisheries	Net price
Indonesia	Average 9% lower than GDP in 1971-1984
Petroleum	Net price
Forests	Net price for harvested timber
Soil	Avoidance cost of fertilizer to provide lost nutrients
Mexico	6-13% lower than NDP in 1985, depending on method of valuation and resources included
Petroleum	Net price and user-cost method
Forests	Net price and user-cost method
Soil	Avoidance cost of fertilizer to provide lost nutrients
Water	Avoidance cost to reduce pollution to acceptable levels
Air	Avoidance cost to reduce pollution to acceptable levels
Papua New Guinea	3.7-10.3% lower than NDP in 1986-1990, depending on assumptions used in valuation
Gold, copper, and silver	User-cost method
Forests	User-cost method

Sources: Costa Rica (Tropical Science Center and World Resources Institute 1991), Indonesia (Repetto et al., 1989), Mexico (van Tongeren, Schweinfest, and Lutz 1991), and Papua New Guinea (Bartelmus, Lutz, and Schweinfest 1992).

National Accounts, Environmentally Adjusted Domestic Product, and Sustainable Income

National accounts, standardized by the United Nations in the SNA, form the core of the economic data system of most countries, providing the basis for many economic decisions. GDP and NDP, central elements of the SNA, are often interpreted as measures of economic well-being. Nonetheless, economists have long been dissatisfied with this narrow interpretation (see, e.g., Eisner 1988 or Moss 1973).

National accounts, with few exceptions, record only actual- or near-market transactions. The environment's contributions to the economy are reflected only partially in conventional national accounts because, in many instances, these environmental resources are not marketed or their market prices do not reflect the full contribution of these resources or their depletion. The

environment is not the only area in which conventional accounts provide less information than policymakers need. Over the past few decades, proposals have been made to revise GDP to reflect a more comprehensive coverage of economic activities, including not only the role of the environment, but also that of the informal economy, the accumulation of so-called human capital, the value of household production and leisure, the accumulation of fixed capital by consumers and governments, capital gains and losses, and the improved representation of such government activities as military operations (Eisner 1988). In the early 1970s, attempts to create such broad measures of welfare[1] included MEW (Nordhaus and Tobin 1973), which adjusted GDP for most of the items listed above Thus, the calculation of EDP is an attempt to measure one of the perceived omissions from NDP, the cost of using natural capital.

Some analysts doubt that a meaningful, single-valued index of the use of natural capital can be created (e.g., Keuning 1992 or Central Bureau of Statistics of Norway 1992). They believe that the multiple criteria needed to assess sustainability are best represented not by a single aggregate measure derived from NDP but by multiple measures in various units. These critics note that information about other important variables like unemployment has usually been handled through the compilation of supplementary statistics rather than revision of GDP.

Conceptually, the two types of problems with EDP as an adjustment to NDP to measure sustainable income are 1) the assumption of a high degree of substitutability between natural and produced capital in production and 2) the basis for imputing prices used to calculate EDP.

Substitution between produced and natural capital. The working definition of the term *sustainable income* implicit in the summary NRA requires that the capacity of the combined stock of produced capital and natural capital remain intact in order to continue generating the same level of income.[2] Since some forms of natural capital are clearly being depleted or degraded, this criterion assumes that produced and natural capital can be substituted for each other. Hartwick (1977) and Solow (1974, 1986) argue that substitutability between produced and natural capital over time is great enough that they can be considered to comprise a single homogeneous stock, an assumption increasingly questioned.

As the understanding of the complexity of natural systems increases, this assumption about the extent to which produced capital can be substituted for natural capital is increasingly

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[1] "Economic well-being" and "economic welfare" are often used interchangeably. Well-being is a loosely defined concept; attempts to measure it usually imply expanding the range of economic phenomena but without specifying any particular method of measurement. Strictly speaking, welfare is the measure of well-being defined by consumer surplus. Unless otherwise stated, welfare in this discussion is used in the sense of well-being.

[2] This is the least restrictive, and for this reason, the most nearly operational interpretation of the conditions required for achieving sustainable income. See Pezzey (1989) for a discussion of definitions of sustainable development.

questioned (see, e.g., Daly 1989, 1991; Pearce, Markandya, and Barbier 1989) Barbier and Markandya (1990, 661) state, for example, that:

> more recent theories now stress the limits to "substitution" between many forms of natural and man-made capital, even for developing countries interested in "drawing down" their natural capital stock in favour of investing in other forms of capital. From an ecological standpoint, a major factor is the failure to consider the economic consequences of the loss in "resilience"--the ability of ecosystems to cope with random shocks and prolonged stress--that results from natural capital depletion.

The scope for substitution is likely to become increasingly limited as natural capital is depleted further and ecosystems encounter more stress. The distinction between natural and produced capital and the limits to substitutability between them are not reflected in EDP.

Interpretation of imputed values in EDP. In order to calculate GDP as an aggregate of many items, goods and services are valued in the same way--on the basis of market price. Determining prices in markets establishes the social value for commodities (in the absence of market imperfections including "externalities") because markets reflect both society's preferences and the costs of production, which reflect the relative scarcity of factors of production. The depreciation of produced capital and the depletion of inventories of produced goods are real costs that an establishment incurs. These costs are also part of market prices and are reflected in the economywide allocation of productive resources.

In contrast, markets are limited for environmental resources; therefore, a monetary value must be estimated if EDP is to be quantified. This value is based on an estimation of what might, could, or should have happened, depending upon the valuation technique. The imputed cost of environmental degradation is a hypothetical cost, not actually incurred and not reflected in market prices or in the allocation of factors of production. In explaining the difference between costs estimated for natural resources, which are not marketed, and goods with market prices, the Central Bureau of Statistics of Norway (1992, 151) has pointed out that:

> The lack of a market [for natural resources] implies that there is no mechanism which compels economic actors to use larger or smaller quantities of "natural goods" so that they end up at a point where the marginal, relative value is equal for all actors and in different situations. Therefore, the "value" of these goods, even at the margin, is not an unambiguous term.

Imputed values are mixed with market values, so EDP cannot be based on a consistent valuation method. A recent article by de Hann, Keuning, and Bosch (1993) reported that "Dutch statisticians argue strongly against attempts to incorporate monetary values for environmental damage into estimates of national income, on the grounds that such exercises do not compare like with like." Keuning (1992) suggests that it is unclear how to interpret EDP that aggregates market values with hypothetical ones. The estimation of EDP is further complicated because of "the introduction, on a large scale, of 'intended' use of resources [i.e., hypothetical costs of

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environmental degradation or resource depletion], without evaluating where these resources are to be taken from, and how this will affect the rest of the economy" (Central Bureau of Statistics of Norway, 1992, 153). If carried out, these hypothetical outlays would affect the allocation of factors of production and prices throughout the economy, potentially changing all values and all market transactions and, in turn, changing GDP and NDP significantly. Estimates of the environmental adjustments to NDP are large enough to have this effect. For example, van Tongeren, Schweinfest, and Lutz (1991) estimated that revision for environmental degradation in Mexico in 1985 would reduce NDP by 6 to 13 percent, depending on the resources included. As the European Economic Commission (EEC) (1992) pointed out, a realistic estimate of EDP requires a model to evaluate how prices and economic transactions throughout the economy change when these activities are carried out and the corresponding expenses incurred. No one has yet attempted such an evaluation. (The Dutch carried out a preliminary estimate that confirmed these changes would be extensive [Keuning 1993, personal communication].)

Omissions: Human capital and the informal sectors. Calculation of NDP requires an estimate of the value of the entire stock of produced capital in an economy and of the depreciation of that stock in a given year. Quantifying these figures poses formidable challenges to both developed and developing countries, but standardized methods can make at least rough estimates. Unfortunately, there are no standardized methods for measuring other activities that are arguably of equal importance for the measure of sustainable income and assessing the use of natural capital.

Of all the omissions from the national accounts, two are particularly important for economic development: 1) the accumulation of human capital and 2) the activities of the informal sectors. No one doubts the importance of human capital for development or the potential for trade-offs between natural and human capital. In fact, depletion of natural resources to fund investment in human capital may be a sensible policy in some developing countries. As for informal activities, they are likely to be extensive and to play an important role in the economic and social relations in developing countries. None of the EDP reviewed here account for nonmarket activities or investment in human capital. Since the purpose of EDP is to provide a single, comprehensive measure of sustainable income, these factors must be taken into account.

Boundary Definitions, Classifications, and Units

Calculating NDP requires subtracting the estimated value of depreciation of all fixed capital assets from GDP. Omission of a significant portion of the capital stock could give a misleading picture of the capacity of the economy. Similarly, EDP is expected to account for the loss of value for all environmental capital (Mäler 1991, Solow 1992). In practice, it has not been (and probably never will be) possible to construct NRA that are comprehensive in their coverage of natural capital.

Comprehensive accounting for all aspects of the use of the natural world, even according to conventions that might make the task possible, would place an enormous burden on the resources of statistical agencies of most countries. Furthermore, much of the data might have

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minimal direct relevance for policy analysis. The construction of NRA requires a delimitation of that portion of the natural world to be included in the accounts. The establishment of this boundary poses both theoretical and practical problems.

It is relatively straightforward to build national economic accounts from establishment-level records using a well-defined classification of inputs and outputs. The same is not true for the environment. Boundaries distinguishing the parts of the natural world or of natural capital to be included are not well defined. Moreover, detailed, comprehensive classification schemes for the environment--analogous to the International Standard Industrial Classification--do not currently exist.

It has been proposed that determining which aspects of the natural world to include in NRA be based on economic principles (see, e.g., Peskin 1993). According to this view, environmental resources should be included that, if they could be marketed, would trade at some nonzero price. This principle for closure requires an understanding of the relationships between the environment and economic activities (in order to determine what services of nature might have economic value), which, in many cases, is far from complete. Even this apparently straightforward closure provides inadequate guidance for describing the natural world by a quantifiable set of variables. The web of interrelated natural and environmental resources would extend far, including resources like solar energy that would surely be marketed if it were technically feasible.

In practice, no NRA attempt to cover all natural capital; they have been limited to natural resources already included in national accounts like metal ores used in production or instances of environmental degradation known to have direct economic consequences like soil erosion. Only one attempt has been made to include environmental benefits as well as costs (U.S. Environmental Protection Agency 1992). This selective implementation of NRA is largely a matter of convenience, and the decision as to where the boundary is drawn is not explicitly discussed in most applications. El Serafy (1993, 36) argues that even a partial accounting "will move economic measurements closer to reality, and this must be regarded as an improvement in the accuracy of such measurements." Whether a partial accounting for the use and depletion of natural capital overstates or understates the severity of environmental problems and their implications for sustainable development are questions that will be answered as the boundary is pushed further.

Data Issues: Need for Valuation and Major Valuation Techniques

Several valuation methods are associated with each of the three categories of deductions from NDP listed at the beginning of this section: defensive expenditures, depletion and degradation of marketed resources, and depletion and degradation of nonmarketed resources. Each category encounters different conceptual and practical valuation problems of varying severity.

Defensive expenditures. In many developed countries, expenditures are incurred for

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pollution abatement and rehabilitation. France, Germany, Japan, Netherlands, and the United States compile summary statistics about selected expenditures for the abatement of pollution to help evaluate their economic performance. It has been proposed that such expenditures be subtracted from NDP because, from the point of view of economic welfare, these expenditures maintain the ability of the economy to function but do not increase economic well-being.

To estimate these expenditures appropriately, it is necessary to distinguish costs incurred for pollution abatement from those associated with the operating costs for an establishment. Establishment records often do not make this distinction, and some costs, such as corporate overhead, cannot be readily attributed to separate functions. Schafer and Stahmer (1989) have developed an I-O model of the German economy to estimate these costs.

The challenge of distinguishing pollution abatement costs from other operating costs is not insurmountable as long as "end-of-pipe" measures are used to control pollution since the cost of the control device or technology is usually easily determined. The process is potentially complicated, however, because new approaches to pollution abatement can include the redesign of production processes, improvements in process control, or even changes in lifestyle that can have other effects and motivations in addition to pollution abatement. In some instances, the new methods can reduce rather than add to an establishment's total operating costs.

Consider, for example, the options for reducing sulfur emissions from coal-burning power plants. One plant can install flue-gas desulfurization equipment to remove sulfur from the exhaust gas stream after combustion, an add-on approach to pollution abatement. Another plant can switch to natural gas, which will likely increase its fuel costs but reduce its other operating expenses and capital costs. A third plant can introduce a new boiler for fluidized bed combustion of coal, which not only removes sulfur during combustion but also is more fuel efficient.

The first plant's expenditures on flue-gas desulfurization equipment qualify as defensive expenditures. The action of the second plant might not be counted at all. It is unclear what proportion of the third plant's investment and its subsequent operating costs should be considered defensive expenditures incurred for pollution abatement. Attempts to deal with other environmental problems like the gradual elimination of chlorofluorocarbons pose even greater problems of definition.

Marketed natural resources. Income from the sale of natural resources is recorded in the national economic accounts, but the depletion of the underlying resource base is typically not recorded in the capital depreciation accounts used to calculate NDP. This asymmetric treatment is said to "exaggerate income and encourage unsustainable levels of consumption" (El Serafy 1989, 10). This problem is especially serious in resource-dependent countries under pressure to increase their populations' standard of living by rapidly extracting or harvesting natural resources. In this case, the proceeds are used for current consumption rather than reinvested in other forms of capital in amounts sufficient to sustain the standard of living. A different method of accounting for resource depletion has been proposed to make this distinction more readily apparent.

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The two principal approaches to revising the representation of marketed natural resources are associated with the work of Repetto and his colleagues (1989) and El Serafy (1989, 1991, 1993). Repetto and his coauthors (1989) estimate an economic rent, called "net price," defined as current market price minus extraction costs. The extraction costs include an estimated "normal" profit. EDP is estimated by subtracting from GDP the net reduction in the stock of the natural resource (extraction minus any increases in estimated reserves) valued at net price. (In Repetto's work, this figure for resource depletion is subtracted from GDP, not NDP, presumably because figures for NDP are not available.)

Practical difficulties are associated with the estimation of a net price. Estimation of the extraction costs and a "normal" profit requires, among other things, an estimate of extraction rates and long-term average price. Given the extreme price swings associated with some resources, it is difficult to establish a meaningful net price from the observed market price. This approach is also criticized for not considering the potential substitution of one resource stock for another (e.g., forest land can be harvested and turned into grazing land) (Peskin with Lutz 1990).

El Serafy's method is able to deal with substitution. Natural resources are viewed as capital assets; the owner's receipts (proceeds from the sale of the resource minus the costs of extraction) include a capital and an income component. The capital component, called a "user cost," is that portion of the earnings that would need to be invested in other assets to yield a permanent stream of income of the same size as the value of the sale. The income component is the remainder of the income; this could be used for consumption. The latter would be counted as income in both GDP and NDP; the former would not be included in either. Estimation of the two components of income requires assumptions, including the extraction schedule, an appropriate discount rate, and probable returns to be obtained from other investments. These assumptions are subject to change over time, resulting in potentially large revisions to previously estimated EDP.

The two approaches can produce different estimates of capital depletion. Repetto and his colleagues (1989) estimated depletion and degradation in Indonesia of soils, forests, and petroleum and gas assets an average of 9 percent of GDP between 1971 and 1984. El Serafy (1993), applying his method to the same physical data for petroleum only and using Repetto et al.'s estimates for other natural assets, calculated figures for depletion and degradation averaging 15 percent of GDP over the same period. Using different assumptions in El Serafy's calculations, different figures could have been obtained.

Both approaches are supported in the literature about capital. El Serafy's method may yield a more useful measure of sustainable income because it not only estimates the depletion of natural resources but also attempts to identify what a country should do about it. El Serafy's valuation process is more complicated than Repetto's, however, and is based on many assumptions difficult to operationalize in the standardized way required for a SNA. Since both methods are plausible and the results of the two will vary depending on the assumptions, it is appropriate to estimate the loss due to the depletion of natural resources as a supplementary analysis rather than as a standard revision of the national accounts.

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The two methods have been applied to both nonrenewable mineral resources and renewable resources, such as forests. The application of either method to resources like forests, which have multiple environmental roles only one of which is marketed (i.e., timber), poses additional problems.

Nonmarketed natural resources. Some natural and environmental resources have either no market prices or market prices that do not fully reflect their multiple ecological roles of value to society. If the depletion or degradation of these resources is to be counted in EDP, a value must be imputed for their full contributions. Economists have developed various valuation methods to answer specific, microlevel policy questions involving nonmarketed resources. Unfortunately, it is possible to obtain different values for environmental damage by varying the method of valuation; in fact, EDP can assume almost any value. The value of nonmarketed environmental resources is not uniquely defined conceptually, so no theoretical basis exists for choosing among valuation techniques. The major methods identified in the U.N. handbook on NRA (United Nations 1993) for valuation of the environment proposed for use with NRA include avoidance cost, repair cost, and contingent valuation. Each method has its strengths and weaknesses.[3]

The avoidance- or maintenance-cost method measures the hypothetical cost of specified actions to avoid environmental damage. (Of course, once the damage occurs, restoration to a given set of standards requires different actions at different costs.) These costs are estimated by defining physical standards for sustainability (e.g., water quality standards), identifying the technical measures needed to meet these standards (e.g., water treatment before discharge), and estimating the cost of implementing these measures based on current market prices. Repetto et al. (1989) used this method to estimate the costs of soil erosion (as the cost of fertilizer required to replace nutrient loss) in Indonesia and Costa Rica. The United Nations and the World Bank used the same approach in Mexico; this is the method most strongly recommended in the U.N. handbook on NRA (United Nations 1993).

The method hinges on the establishment of the physical standards for sustainability, such as acceptable concentrations of various chemicals in the water supply or pesticide residues in meat. Unfortunately, natural scientists often cannot define such standards with any certainty; they are based on estimates of a probability function and political decisions about how much risk a population should accept. The standards are typically revised as knowledge about the environment increases (e.g., tighter standards for clean air and water, the banning of substances in certain applications like DDT or asbestos in public buildings in the United States). Thus,

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[3] Various other valuation techniques have been developed by economists. This paper addresses specific issues regarding valuation techniques for NRA and focuses on the valuation techniques recommended by the U.N. (1993). Consequently, several techniques are not discussed, such as wage-risk studies, hedonic property prices, and travel-cost approaches. (For a comprehensive review of valuation techniques, see, e.g. Pearce, Markandya, and Barbier 1989 or OECD 1989.)

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political decisions partially determine the value of EDP, which is subject to substantial revision as standards, as well as political preferences, are revised (Keuning 1992). These standards differ among countries and have already been the basis for trade disputes (see Duchin, Lange, and Kell forthcoming).

The repair-cost approach to valuation attempts to identify the costs society would incur if sustainability standards were imposed after environmental damage already occurred. The approach asks how much it would cost to restore the environment to some minimum standards of acceptability. The approach requires information similar to the avoidance-cost method: a definition of physical minimum sustainability standards for various environmental functions (the repair need not restore the environment to its original state if that state exceeds the standard), identification of the technical measures needed to meet these standards, and an estimate of the cost of implementing these measures. The repair-cost approach also requires use of contingent valuation if it is extended to include the effect of degradation of landscape and recreation value to consumers (United Nations 1992).

Each valuation method is appropriate in specific circumstances. The repair-cost approach is useful in measuring the actual cost of reversing environmental damage at a given time. The avoidance-cost approach is useful for determining the costs of alternative approaches for complying with specific environmental standards. For example, a government can conduct a cost-benefit analysis (CBA) to decide whether to impose emission restrictions on an industry, how stringent they should be, and what form they should take. One part of the analysis would estimate the costs of repairing potential environmental damage that would occur if no regulations were imposed (repair cost). Another part of the analysis would determine the costs of avoiding environmental damage associated with the alternative technologies that industry could use (avoidance cost).

Contingent valuation is used when no directly comparable market costs are available; this is the case, for example, in estimating the value the public places on national forests. The two alternative methods of contingent valuation are 1) willingness to pay and 2) willingness to accept. The first is a survey-based estimate of how much people would be willing to pay to avoid environmental degradation; the second is an estimate of how much people would have to be paid to accept such degradation. Willingness to pay is more commonly used than willingness to accept.

Contingent valuation is highly problematic. Surveys of what people might be willing to pay do not necessarily bear any relation to what they would actually pay if required to do so or to what they would pay if they were more fully informed about the nature and implications of the problem. The latter would require that natural scientists be able to establish standards of physical sustainability with certainty and that the public understand the standards and the probability distributions associated with them. The public would also need to be able to convert estimates of future damage into current monetary values. The income of the population surveyed affects such valuations. Poor people are usually unable, and therefore unwilling, to pay as much as wealthier people for the same levels of environmental quality.

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Regarding the role of contingent valuation in constructing NRA, the United Nations states that contingent valuation and related methods "are intended more for ad-hoc analyses and research than for routine data collection" (Bartelmus and van Tongeren 1994, 11). They go on to explain that:

> Monetary valuation and economic analysis reach their limits where such valuation becomes arbitrary with increasing remoteness of the results of (non-economic) human activities and natural processes from economic output....An attempt to push monetary valuation further into the realm of non-economic (dis)amenities is the application of the above-mentioned "contingent valuation" to environmental effects on human health and welfare. Well-known difficulties of declared willingness-to-pay in project-oriented cost/benefit analyses seem to disqualify this approach from use in routine accounting at the national level.

There have been no examples of the application of different valuation techniques for nonmarketed natural resources in the same country that would illustrate how different the estimated values of EDP could be. The application of different methods for valuing marketed natural resources yielded widely differing figures. To highlight how these methods of valuation differ, their applications to the same problem are compared in Table 3; the example is the discharge into a river of a toxic substance that could have been avoided by the use of low-cost controls. Even though the discharge was not avoided, the avoidance-cost method would value the environmental degradation at this low cost. The actual damage in this example can be extensive if fish and wildlife are killed and the water is rendered unfit for agriculture or other human use. Thus, the cost of clean up or the repair cost is high. If there is irreversible damage, such as that associated with extinction, then no amount of money is relevant. The willingness-to-pay approach will produce either high or low values, depending on the public's income, knowledge, and social values. Similarly, willingness to accept could produce a wide range of figures.

None of the four valuation methods addresses how to value irreversible damage, such as extinction of species or serious nuclear accidents with effects that can persist for tens of thousands of years. In addition, some steps of all the valuation techniques rely on prices established in well-functioning surrogate markets (e.g., for both labor and capital), which often do not exist in developing countries. The choice of a valuation method for components of EDP cannot be readily standardized and will depend on the use to which it will be put.

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Table 3. Alternative methods of valuation and their implications for EDP

Example: A company discharges a toxic substance into a river, killing fish and other wildlife and making the water unusable for agriculture and humans. The discharge could have been prevented or cleaned up before it reached the river at low cost but was not. The value of the damage to the environment that would be included in EDP is described using alternative methods.

Avoidance Cost:	The cost to have avoided the damage to the environment in this example is **very low.**
Repair Cost:	If measured on the basis of costs of repair or restoration, the value will be **very high**; if damage is irreversible, costs cannot be computed.
Willingness To Pay:	If people are asked how much they would pay to avoid the discharge, the answer will depend on their relative incomes, the value they assign to future generations' use of the environment, how well-informed they are about the consequences of the problem, and how seriously they regard those consequences and could be **high or low.**
Willingness To Accept:	If asked how much compensation they must receive to accept such damage, the same people may give a **high or low** figure, often higher than the willingness-to-pay figure.

Source: Central Bureau of Statistics of Norway (1992, 152).

Additional valuation issues. The valuation of renewable resources poses other serious problems in addition to those identified above. Repetto and his coauthors (1989), for example, base the value of forest accounts solely on the market value of timber. Their approach also excludes other ecological and economic roles of forests, such as watershed protection, soil erosion and flood control, local climate control, wildlife habitat, supply of nontimber products, and tourist attraction. Yet, it is precisely the complex and multidimensional contributions of the environment that need to be maintained for sustainability (Myers 1988).

Similarly, Repetto bases soil accounts on estimates of the cost of fertilizer needed to replace nutrients lost through soil erosion. He assumes that commercial fertilizer and soil nutrients are close substitutes and that the only important characteristic of soil is the nutrient content. Other characteristics, however, such as soil structure, are equally important and cannot be replaced; in fact, commercial fertilizers can further degrade soils. In a separate section of the soil accounts for Costa Rica, an additional potential effect of soil erosion is discussed (the siltation of a particular dam), but this account is not included in the calculation of GDP.

Such studies tend to treat environmental costs and benefits asymmetrically. While most of these efforts propose adjustments for environmental damage, they do not account for

environmental benefits like the recreational or other nonmarketed value of national forests. Peskin (1991) proposes to include both environmental costs and benefits and has implemented this approach in a set of accounts for the Chesapeake Bay region (U.S. Environmental Protection Agency 1992). The valuation methods were not discussed.

Policy Applications

The objective of the summary NRA is to provide a time series of a single aggregate measure, EDP, to assess the performance of an economy. Changes over time in the EDP indicate whether the economy is growing sustainably, stagnating, or declining, and at what rate. Summary NRA studies seldom report how policymakers use these figures or, with the exception of Mexico,[4] plan to use these numbers other than for illustrative purposes.

El Serafy (1993) notes that the estimate of natural capital depletion used to calculate EDP may apply to the construction of other indicators to evaluate a country's performance or to determine macroeconomic policies, such as structural adjustment programs. He has identified three such uses: 1) the measure of national savings and investment, 2) the incremental capital to output ratio, and 3) the calculation of the balance of payments. El Serafy notes the need for sectoral detail to assess many effects of macroeconomic policies like structural adjustment; these data would need to supplement the summary NRA. The sectoral data provided by management-oriented NRA could be used for this type of assessment.

El Serafy uses as an example tracing the effects of policies associated with structural adjustment, including the removal of subsidies or currency devaluation, which might raise the price of fertilizers and petroleum products. This will result in cost increases in various sectors, which will be passed on to other sectors in the form of higher product costs, through several rounds as the direct and indirect effects of these price increases spread throughout the economy. Some sectors will substitute other inputs for the now more costly ones, such as the substitution of fuelwood and charcoal for kerosene, with potentially significant environmental effects, such as increased deforestation. Sectoral resource, environmental, and economic data provided by management-oriented NRA can help determine the full environmental and economic impact.

Evaluation

From a conceptual point of view, none of the NRA that have been constructed provide a comprehensive measure of sustainable income. The practitioners claim, however, that sustainable income is the appropriate objective of policy and that their efforts have produced a number closer to sustainable income than that provided by conventional accounts. Some problematic assumptions, like the substitutability between different types of capital, could be

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[4] ~~The NRA for Mexico are part of the management-oriented approach to NRA and are~~ discussed in more detail in Section 3. They are included here because they were also used to estimate EDP.

refined through further empirical work and could possibly be handled by differential weighting of capital, if necessary. Modeling exercises might be able to resolve some of the problems concerning the mix of actual and imputed values in EDP. The omission of human capital accumulation and the informal sector is not generally addressed.

From a practical perspective, EDP as a measure of sustainable income is only as good as the underlying physical data about use of natural resources, valuation methods for nonmarketed resources, and the national accounts themselves. For numerous reasons, data problems are more likely severe in developing, rather than in the developed, countries.

The case for EDP is strongest in countries where the environmental problems are mostly limited to depletion of natural resources for which market prices exist. While it is feasible to calculate a value for depletion of marketed resources, different methods of doing so result in different values for EDP or sustainable income. This problem might be mitigated by an international consensus on statistical methods. Nonetheless, wide fluctuations in the market prices of resources will result in volatile values for EDP.

Extension of EDP to include nonmarketed environmental and natural resources, like soils, water, and air, through imputed valuation is more problematic. Implementation of the valuation techniques requires many subjective judgments and can result in a wide range of values for environmental damage. This problem is not likely to diminish with improved data; it results from the use of different, equally plausible valuation techniques. Which one a policymaker chooses to use cannot be standardized; it depends on the policy questions asked. Some proponents of EDP find even the theoretical--not to mention practical--problems with valuation of these nonmarket resources so great that they suggest the use of physical measures to judge an economy's sustainability rather than the estimated monetary ones that economists usually prefer. For example, Solow (1992, 21) has observed that:

> Marketed commodities, like minerals or renewable resources, are much simpler [than environmental assets]. I have admitted fairly and squarely, how much of my argument depends on getting the shadow prices approximately right. Ordinary transactions prices are clearly not the whole answer; but they are a place to start. With environmental assets, not even that benchmark is available....I think the correct conclusion is the one stated by Karl-Goran Mäler: that we are going to have to keep depending on physical and other special indicators in order to judge the economy's performance with regard to the use of environmental resources.

The power of the national accounts stems from the fact that they provide a standardized set of accounts in which the same data are compiled in the same way throughout the world. In contrast, there is no basis for standardizing valuation of all uses of natural resources. While these valuation analyses may be useful, they are exploratory, not definitive; they are more appropriate as supplementary analyses than as a basis for revising national accounts.

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Whatever valuation method is chosen, an estimate of the value of environmental degradation requires sound underlying physical data. These can usually be obtained easily for marketed resources. Data for nonmarketed resources often must be compiled at a detailed level and are not systematically accommodated in the summary NRA. Because the summary NRA focus on estimating a single aggregate number to subtract from NDP, a largely top-down, aggregate approach to constructing accounts is adopted. Issues related to valuation are emphasized. For this reason, issues related to the physical measures have not received appropriate attention in this approach to NRA. While problems remain, they have received more attention in countries that have compiled management-oriented NRA. This is one reason the Swedish government gave for not supporting the calculation of EDP from the satellite accounts it intends to construct (Commission for Environmental Accounting 1991).

EDP relies on good estimates of conventional measures of NDP and GDP. Problems with the poor quality of measured GDP in many developing countries, the even more problematic estimates of the depreciation of produced capital used to calculate NDP, and the omission of economic activities like capital formation in the informal sector make calculating sustainable income from national accounts difficult in these countries. Estimates of NDP may be highly variable from one year to the next because of measurement problems. In view of these problems, the time trend of NDP, and thus of EDP, may not be a reliable indicator of sustainable development.

Assuming that a meaningful EDP could be estimated, would it aid policymakers in managing their economies and their natural resources? As Henry Peskin (1993, 4) notes:

> An implicit assumption [of summary NRA] appears to be that if political leaders had been presented with improved NDP estimates, they would have avoided serious errors in the management of their economic, resource, and environmental policies....[But summary NRA] implies better policy only if one knows how to respond to the "score."

In suggesting the range of plausible responses to NRA that produce an "adjusted NDP" 4 percent lower than conventional NDP due to the extraction of natural resources, Peskin (1993, 4) goes on to ask:

> Does this mean that the country would have been better off economically had the resources been less exploited? This would not necessarily be the case if the exploitation of the natural resources provided the income that permitted investment in other forms of national wealth such as plant and equipment and human capital. It is quite possible that these other forms of wealth yield higher economic returns than did the exploited natural resource wealth. Determining whether or not this is the case is not a trivial exercise.

As others (e.g., El Serafy 1993) have noted, determining how best to respond to a situation revealed by an indicator--assuming the indicator is reliable--would require sectoral information about resource use to supplement the summary NRA.

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Measures of GDP are comparable across nations, but this comparability will be lost for environmentally adjusted GDP because countries account for different environmental problems and use different valuation techniques. In a review of NRA practice, the Swedish Commission concluded that experiments to monetize physical accounts could be interesting and of potential value as a basis for further analysis but that nothing could be gained by estimating EDP. The Swedes concluded this, in part, because of the conceptual and practical difficulties in calculating revised GDP and because of the loss of a generally accepted measure of economic performance this would entail. The authors concur with this assessment and describe in Sections 3-5 a more useful approach to NRA.

Even if agreement could be reached on standardized treatment of different classes of natural resources and valuation techniques, a fundamental criticism of EDP raised by Keuning (1992) and shared by many others remains: valuation is not an accounting exercise but a modeling challenge. The estimates of GDP and EDP that result from such models, based on changes throughout the economy that would result if the environmental costs had been incurred, bear little resemblance to the transactions that occurred in the economy in a given year.

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3. Management-Oriented Natural Resource Accounts

Management-oriented NRA are constructed to serve both monitoring and analytical purposes. These NRA can be used to calculate summary physical measures of resource use and environmental degradation at a point in time and trends over time; they can also be used to calculate associated costs and income flows including EDP (subject to the difficulties described in Section 2). In addition, management-oriented NRA provide detailed physical information about the state of the environment needed for many types of analysis related to sustainable development.

The flow accounts of these NRA are similar in structure to the interindustry portion of the national accounts in that they record the extraction, use in production, and consumption of resources and the discharge of waste materials associated with each economic activity, including consumption and nonmarket activities of households. Additional accounts are compiled for stocks of selected natural resources. Quantities are initially compiled in physical units supplemented by information about unit prices in those cases in which market prices are available. Tables 4a and b give examples of the types of accounts that can be constructed. Table 4a shows emissions of sulfur dioxide and nitrogen oxides in 1989 associated with each of 22 economic sectors in Norway; Table 4b shows the shares contributed by each major sector to the economy and to several major environmental problems in the Netherlands.

Due to the need to provide a policy interpretation for the physical data, the NRA may be extended either through incorporating physical indicators or applying monetary valuation techniques to create another set of (partially) monetized NRA (Perrings et al. 1989; Commission for Environmental Accounting 1991; van Tongeren, Schweinfest, and Lutz 1991; United Nations 1993). Of course, imputed prices are subject to the same difficulties with valuation discussed in Section 2. This use of management-oriented NRA differs from the summary NRA approach in the former's insistence on the prior construction of a complete set of physical satellite accounts and in its stress on the experimental nature of any valuation technique.

The potential uses of management-oriented NRA are much broader than those of summary NRA. The management-oriented approach faces different conceptual and method problems, in part, because it aims to provide data for use with policy models. Construction of the summary NRA does not depend on the specific questions to be asked or require compilation of detailed information or the systematic use of standardized economic classifications. To construct NRA intended for environmental and resources management purposes, however, the policy questions to be asked and strategies to be evaluated need to be identified from the outset. In fact, the identification of policies and strategies to be analyzed must be part of the process of constructing NRA because the aspects of the natural world to be included in the accounts, the definition of a classification scheme, and the units will be determined, in part, by these objectives. In addition, a modeling framework for applying these data to policy questions may be required. These requirements make the construction of management-oriented NRA a more ambitious undertaking.

Table 4a. Sectoral emissions of sulfur dioxide and nitrogen oxides from the Norwegian natural resource accounts in 1989

Sector	Emissions (10^6 metric tons) SO_2	NO_x
Total	59.4	232.9
Energy	7.3	45.6
Extraction of oil and gas	1.3	41.9
Extraction of coal	0.0	0.0
Oil refineries	5.1	2.1
Electricity and water supply	0.9	1.6
Manufacturing and mining	36.0	25.0
Pulp and paper	3.8	1.4
Industrial chemicals	7.5	5.3
Mineral products	3.4	5.4
Iron and steel	11.6	6.4
Other metals	5.3	1.6
Metal products, boats, and platforms	0.4	1.0
Wood, plastic, rubber, and chemical products	1.6	1.4
Consumer goods	2.5	2.6
Other	16.0	162.3
Construction	0.5	6.8
Agriculture and forestry	0.8	6.5
Fishing and hunting	1.9	31.4
Land transport	2.1	27.3
Sea transport	5.7	27.5
Air transport	0.1	3.0
Other private services	1.2	16.8
Public activities (municipal)	0.4	0.3
Public activities (state)	0.5	6.2
Private households	2.8	36.4

Source: Central Bureau of Statistics of Norway (1992).

Table 4b. Economic contributions and environmental impacts of major economic sectors in the Netherlands

Sector	Economic Contribution (%) NDP	Labor	Export
Agriculture	4	4	6
Manufacturing	20	19	69
Electric power	1	1	0
Construction	6	8	1
Transport	5	5	10
Services	64	64	16

Sector	Environmental Impact (%) Green-house gas	Ozone deple-tion	Acidifi-cation	Eutrophi-cation	Solid waste
Agriculture	13	0	47	85	5
Manufacturing	36	54	24	11	40
Electric power	28	0	10	1	1
Construction	1	25	1	0	21
Transport	6	6	12	1	13
Services	17	15	7	1	20

Source: de Haan, Keuning, and Bosch (1993).

Objectives

Management-oriented NRA provide a structured framework for monitoring a range of resource variables, such as soil erosion, water pollution, fuelwood use, and loss of biological diversity. The NRA themselves are a compilation of physical data; their interpretation requires:

- physical standards, such as sustainable yields (forests), sustainable extraction rates (water), or tolerable concentrations and toxicity levels (pollutants)
- economic valuation techniques for assessing costs and benefits

Criteria are required, for example, to evaluate Norway's 1989 emissions of 59.4 million tons of SO_2 into the atmosphere (Table 4a). The Norwegians do not include physical standards or valuation in their accounts. The interpretation is carried out separately. The Dutch, however, are moving toward including physical standards.

The most ambitious application of management-oriented NRA is to incorporate NRA into economic/environmental tools and models for policy analysis and planning at the regional and national levels or for sectoral and project management. NRA can be used in CBA and operational research models for sectoral and project analysis, or in Social Accounting Matrix (SAM)/Input-Output (I-O)/Computable General Equilibrium (CGE) models at a regional or economywide level (see Box C). The U.N. handbook and a recent study by the Congressional Budget Office (CBO) list several potential applications of NRA for policy analysis. Both assume as an analytical framework that the NRA are used to extend a country's I-O table. While the examples cite the use of an I-O model, it is possible to use the extended I-O table in other modeling frameworks, such as the SAM-based and CGE models described below. Of course, the potential applications of NRA are not limited to those given here.

Box C

The three major categories of models identified for use with NRA are I-O, SAM-based, and computable CGE.

I-O models are based on data from an I-O table. The strength of these models lies in their portrayal of sectoral interrelations and effects and their relation to the macroeconomy (at a regional or national level). They are used to trace effects of economic policies on employment, output, energy and investment requirements by sector.

SAM-based models expand an I-O table by providing more detailed information about institutions, especially households. Models based on these data are useful for examining distributional effects.

CGE models are generally based on I-O tables or SAMs but achieve optimal "equilibrium" solutions by imposing broad assumptions about market clearing conditions and substitutability of inputs.

The U.N. handbook (United Nations 1993, Chapter V) explains how the NRA can be used to extend the I-O table and provides the following examples of uses for NRA in policy analysis:

> Depending on the nature of environmental-economic interactions and the focus on key policy parameters and variables, a wide variety of different environment-related input-output analyses can be conceived. Based on the different SEEA [System of Environmental and Economic Accounting] versions, the following types of analysis could be usefully explored:

a) Analysis of monetary flows of environmental protection activities. Input-output models could be used for analyzing data according to the concepts of the SEEA, versions II and V.6, that is, the externalization of internal environmental protection activities. Such analysis could determine the economic importance of environmental protection activities and identify the burden of the environmental protection costs directly and indirectly associated with the production of particular branches or product groups;

b) Analysis of physical flows of raw materials, produced goods and residuals. Physical flows could be linked to monetary data without introducing imputed environmental costs, based on version III of the SEEA. The analysis would aim at studying international implications with regard to the depletion of natural assets, the production of goods and the destination of residuals. Furthermore, data on the use of raw materials and outputs of residuals could be linked with the flows of produced goods in an application of the concepts of materials/energy balances;

c) Analysis of imputed environmental costs at maintenance values. Based on version IV.2 of the SEEA, input-output models could, for example, determine the indirect imputed environmental costs connected with international trade;

d) Analysis of maintenance of natural assets. Based on version IV.2 of the SEEA, models could study the impacts of changes in the structure of inputs and in the structure of final uses connected with the maintenance of natural assets. In a first step, the immediate impacts of maintenance activities on economic structures could be introduced as exogenous changes. In a second step, indirect effects of these structural changes on the use of raw materials and on the output of residuals could be analyzed (United Nations 1993, 144-45).

Chapter VI of the draft U.N. handbook (United Nations 1992) provides simple mathematical examples of how some of these analyses might be carried out.

The CBO's report (1994) points out that, by linking the NRA to the I-O tables to create an expanded I-O table, a model can be used to address the environmental effects of different economic policies. Two examples are given:

Distributional Impacts of Environmental and Natural Resource Policies

The benefits and costs of environmental and resources policies fall more heavily on some industries or income groups than on others. Improved water quality especially seems to favor higher income groups since most of the improvement is in nonurban recreation sites. Employment in industries that pollute more, such as chemical and paper manufacturing, could be most affected by tighter air quality standards. Such a perception--whether correct of not--can cause political resistance to new initiatives that might result in policy improvements.

The input-output accounts can be especially useful for analyzing the impact of legislation on different industries. Detailed models of the payments sector in I-O tables have also been developed to predict the effect of policies on income distribution. The Forest Service has incorporated one such simulation in its regional planning model, IMPLAN (Impact Analysis System for Planning). One way of improving information about the distributional effects of environmental and natural resource policies is to incorporate data on environmental and natural resource service flows into the accounts.

Links Between Trade and Environmental and Natural Resource Policies

A traditional justification for trade measures and sanctions is that they retaliate for activities that place the United States at a competitive disadvantage. A case could be made that pollutants that cross boundaries have this effect. Discharges of pollutants by other countries may not only affect production costs in the United States, but could affect them differently than in the home country. For example, the effects of greenhouse gases on local climate patterns vary depending upon the latitude, size of land mass, and so on.

Trade restrictions have not been used when a country's production and processing methods result in excessive discharges of pollutants such as carbon, sulfur or nitrogen oxides, or chlorofluorocarbons across national boundaries. One reason is the difficulty in determining the effect of transboundary pollutants on industry costs. Expanding the input-output tables to include the use of waste disposal services and identify abatement costs could help in identifying primary and secondary costs of transboundary pollutants (CBO, 1994, 10-11).

Boundary Definitions, Classifications, and Units

Management-oriented NRA are based on two sets of classifications, one for environmental variables and one for economic activities with which environmental variables are associated. Classifications for economic activities are consistent with those used in the economic accounts. The framework of the management-oriented NRA is typically comprehensive with respect to economic activities but not with respect to environmental categories; more variables or greater detail are provided as required for addressing a country's particular problems.

The national accounts, extended to include household production and consumption activities, provide the classifications for economic activities in management-oriented NRA. This system links economic activities at a detailed sectoral level and provides principles for sectoral aggregation. A comprehensive economic framework is required because multiple, competing sectors use many natural resources, such as water, but the level of sectoral aggregation can vary depending on the interrelations and the expected feedback among economic and environmental variables. For example, industrial sectors might be represented in considerable detail for air pollution accounts, while agriculture would be highly disaggregated in accounts for soil erosion or water use.

A classification scheme for environmental variables must be broad enough in scope and detail for the questions being asked, given current understanding of the relations. These need to be determined by multidisciplinary criteria so that all related environmental variables are included. Management-oriented NRA may be compiled at different levels of economic detail for each environmental resource. For example, the Norwegian accounts for energy resources and air pollutants are compiled for 141 economic sectors, fishery accounts for a handful of economic sectors, and forestry accounts for an intermediate number of sectors. This practice makes integration of all resources into a single framework problematic. The accounts for energy resources and air pollution have been designed to be used together; the forestry and fishery accounts are used independently of the other environmental accounts.

In Norway, it may be appropriate that the accounts have been designed for separate use. The accounts for each resource need not be constructed at the same level of detail for economic sectors, but it is important for policy analysis that a trade-off of one environmental problem for another be noted. In a developing country where fuelwood is a significant source of energy, it might be important to compile accounts for forestry and energy resources at the same level of economic detail so they could be integrated in the same analysis. Levels of aggregation of economic sectors should be chosen so that all relevant environmental variables can be included in the analysis; rules for aggregation and disaggregation are needed if information is not collected at the same level of detail for each environmental resource.

The classification scheme specifies not only the types of environmental and natural resources to be included but also the NRA's geographic and temporal coverage. Representation of the extraction and use of minerals usually corresponds closely to the classifications used for economic data. Management of many environmental resources of greatest concern in developing countries, such as forests and soils, may not. These resources may, for example, be associated with watersheds that form critical subregions within a country or they may cross national boundaries. While economic data typically are collected on an annual basis, the annual flow of some resources, such as water, may be less important for strategic planning than the seasonal flow.

Current environmental problems are said to determine classification systems for natural resources in the NRA that have been constructed. Norway's experience has shown that identification of currently important natural resources differs from identification of resources critical for a development strategy. Consequently, basing the classifications on the former only does not guarantee that the NRA will be useful for policy analysis.

Data Issues: Compiling the Physical Database

In much of the literature about NRA, extensive discussion centers on the conceptual similarity between NRA and national accounts and between natural and produced capital, but an important issue has been overlooked: the essential difference between environment and economic data, which affects data collection and integration. The compilation of economic data can rely on an establishment's records of how much electricity or paper is purchased or sold in a given

year. The United Nations provides extensive guidelines about collecting these data and statistical methods for compiling detailed information in standardized classifications. Environmental data, in contrast, often cannot be observed or measured directly. A logging company or farm household has no records of how much soil erosion it causes because no such accounting data exist.

NRA need to be constructed from data observed, measured, or estimated for highly disaggregated activities in specific geographic locations. In some instances, information can be obtained from case studies, project evaluations, sectoral surveys, or other sources that may not be complete or comprehensive and may report data in different units. These microdata are then associated with sectoral economic activity. For example, soil erosion can be measured by installing soil traps on an experimental farm. It is usually impractical to compile data in this manner for every farm so these data can be extrapolated for other farms with simple or complex adjustments to account for differences in factors that affect soil erosion like climate and environmental conditions and farm management practices. Similarly, estimates for the emission of air or water pollutants, such as those provided for Norway in Table 4a, are derived from a combination of empirical measurement and modeling.

Problems with estimating the physical data apply to both management-oriented and summary NRA, although the former faces additional challenges. To estimate EDP, a single estimate of the aggregate environmental changes like the total emission of sulfur dioxide into the atmosphere or soil erosion often suffices. Management-oriented NRA require this information at a sectoral level; the information may be more reliable at this level of detail, but its collection requires more effort. The association of microdata with sectoral activity is fairly straightforward for use of some natural resources, such as minerals. By contrast, activities that span several sectors can affect such environmental assets as soils and forests. For example, the same land can be used for farming and grazing livestock at different times. The causal links between economic activities and changes in resource quality can be difficult to define.

Unfortunately, methods for estimating microdata and associating them with sectoral-level activity is not discussed in any study that has produced management-oriented NRA or in the U.N. draft handbook on NRA (United Nations 1992). There is currently no set of standard methods or systematic description of exploratory methods for compiling data about the environment for NRA. Much of the work done is apparently still ad hoc.

The United Nations' SNA represented significant progress in national income and product accounting because it describes standardized accounts, compiled in a standardized way, that most countries follow. The development of standard methods for the collection of environmental data and the association of these data with sectoral economic activity are an important area for future work for both approaches to NRA. This work will require collaboration among natural and environmental scientists, engineers, and economists.

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Moving From Monitoring the State of the Environment to Analysis

Management-oriented NRA are compiled with the expectation they will be useful for strategic analysis and decision-making, as well as monitoring. Alone, however, the accounts provide information only about the state of the environment in a given year--models are required to use NRA for analysis. Building such models and ensuring their effective use require:

- identifying specific alternative policies (or scenarios) to be evaluated
- projecting environmental parameters under alternative potential environmental conditions
- constructing a model integrating environmental and economic relations and
- projecting environmental and economic parameters (such as growth in GDP and future production technologies) under alternative assumptions.

Scenarios need to be formulated in terms of the environmental and economic categories of the accounting framework that was designed to reflect these policy requirements. Development strategies are often formulated in broad, general terms or in terms of the detailed functions of each ministry or department concerned. The representation of a scenario requires a medium level of detail that integrates the concerns of numerous government agencies. Different ministries often are responsible for forestry, agriculture, energy, and water; each ministry uses different data, methods, and classifications, all of which must be reconciled for designing a scenario to be analyzed. Projections about other aspects of economic development, likely the responsibility of yet another governmental division, also need to be integrated. Projecting environmental parameters requires an understanding of the mechanisms that link environment to economic activities. This is not simply a matter of collecting data but a multidisciplinary effort in which economists work with natural scientists and researchers with on-the-ground experience.

Construction of management-oriented NRA is complete or underway for Botswana, France, Mexico, Netherlands, Norway, Philippines, and Sweden. More countries are added each year. Typically, management-oriented NRA are used with I-O, SAM-based, or CGE models. The United Nations handbook and the CBO recommend linking the NRA to the I-O tables that are already part of the national accounts (United Nations 1993, CBO 1994). The advantage of this integration is that it brings the diverse projections and assumptions into a common analytical framework that can ensure consistency and identify interrelations. The data requirements for such an undertaking can be considerable. (See Section 4.)

Policy Applications

With the exception of Sweden, which has not yet implemented NRA, the countries mentioned above have compiled management-oriented NRA. Of these, Norway, Philippines, Netherlands, and Botswana have begun or plan to use them. Full accounts for Norway, compiled

for the past 15 years, have been used extensively, albeit unevenly. The Netherlands and the Philippines have compiled NRA in the last several years and are beginning policy applications. The accounts for Botswana are not yet completed and, consequently, have not been used for policy analysis. Nonetheless, the model with which the accounts will be used and several potential policy applications have been identified. There has been no experience in the use of monetized NRA for policy analysis. In France and Mexico, discussion of potential applications remains at a general level. At the time of this report, the NRA for Mexico had not yet been applied; however, since they were constructed specifically to be linked with the widely used I-O model of the economy, the authors expect they will be used in the future.

Norway. Norway began compiling NRA in 1978 and has used the accounts to formulate policy and long-term economic strategy at the macroeconomic level and for specific natural resource sectors (Alfsen 1991; Alfsen, Bye, and Lorentson 1987). These NRA include annual use of eight fuel and nonfuel minerals, forests (by species), and fish (by species, location, and age), as well as the annual emissions of nine air pollutants by at least 141 economic sectors (more detail is provided for the energy accounts). The accounts currently include information about 16 types of land use and five categories of soil fertility. Accounts for water, solid and hazardous waste, radiation, and noise will be added in the future.

The Norwegians consider their energy accounts the most useful, judged by intensity of use. The Ministry of the Environment and the Ministry of Oil and Energy use these accounts for monitoring and, with a CGE model of Norway, for analysis. Conducting analyses of policy scenarios within a comprehensive framework ensures that economywide costs, benefits, and effects measured in units other than prices are considered. Explaining the importance of modeling in setting environmental policy (in this case a sulfur tax), Alfsen, Bye, and Lorentson (1987, 59) note:

> Taxes on SO_2 emissions from manufacturing industries not only augment costs and prices in the affected sectors. Higher costs are passed on to other producers via increased input prices, inter alia inflation is increased, competitiveness reduced, capital markets affected, sector composition changed, and the amount of emissions of other pollutants affected. These indirect effects can be significant, but are not picked up by partial analyses of the problem.

The NRA provide the sectoral information about sulfur emissions, which allow estimation of the effect of a tax on each sector and the rest of the economy. The data are used to project future emissions of sulfur and where different abatement policies would be most cost-effective. Data from the NRA are used regularly in economic models for energy planning, in particular, to project future requirements for fuels under alternative policy scenarios and assumptions about economic growth and technological structure. This, in turn, is used to project future investment requirements in energy sectors and to assess the environmental consequences of expanded extraction and substitution among energy sources (oil, gas, coal, hydroelectric). The energy and air pollution accounts are also used to explore the economic and environmental effects of different energy taxes for reducing carbon emissions (Alfsen 1994).

The Ministry of the Environment uses the land accounts to formulate policy for coordinating the demands of such competing interests as hydroelectric power plants, reindeer farming, infrastructure, wilderness protection, and recreational land use. Existing accounts are used to analyze the environmental consequences of alternative land uses and the distribution of pollution.

In the case of fishery, forestry, and nonfuel minerals, the accounts were relatively easy to establish but are not used widely (Alfsen, Bye, and Lorentson 1987). For the nonfuel minerals, this may be because their use and associated environmental effects are far more concentrated in a few economic sectors than those associated with the use of fossil fuels. In this sense, the NRA's comprehensive framework does not offer an advantage over other statistics already collected about use of these minerals. For forestry and fishery accounts, lack of an appropriate framework for economic modeling to analyze these data has been identified as an obstacle to their use.

The Philippines. The Philippines NRA Project, with support from USAID, has recently completed forest sector accounts (physical and monetary accounts) with detailed information about several tree species in each region of the country. The forest accounts provide useful information about the state of the forestry sector, but the study's authors concluded that NRA that focus on a single sector and resource do not allow policymakers to address interactions among economic activities and their effect on the environment, including off-site effects and trade-offs among economic activities (Natural Resources Accounting Project 1991). Consequently, a second phase of this project was launched in 1994 to construct more comprehensive NRA to include air and water pollution by all sectors of the economy and the depletion of fisheries, minerals, soils, water, as well as forests. Many policy applications of the extended NRA are planned (Natural Resources Accounting Project 1993), including:

- modeling the environmental impact of a more open trade regime
- modeling sectoral water and air pollution and the economywide costs and benefits of alternative means to reduce pollution
- assessing the economic impact of alternative land-use policies, such as slope limits for forest land classifications, logging bans, and limits on conversion of prime farmland.

The Netherlands. In 1993, the Netherlands began to compile NRA integrated with the national income accounts in a system designated as a National Accounting Matrix Including Environmental Accounts (NAMEA) (de Haan, Keuning, and Bosch 1993). The Central Statistics Office of the Netherlands has considered NRA for several years, but the decision in 1993 to begin compiling the data was, in part, a response to the Ministry of Finance's request for information about the effect of a carbon tax on the international competitiveness of each of the affected industries compared to those of the other members of the European Union (S. Keuning 1993, personal communication). While the NRA allow the calculation of the effect of a carbon tax on each sector's costs of production and an assessment of its effects throughout the Dutch

economy (as described by the United Nations and CBO), NRA would be required for each other country in the European Union to assess changes in international competitiveness and potential changes in trade patterns.

The Dutch NRA are physical accounts that record the use of resources and the discharge of pollutants. The accounts are organized around what are considered the most pressing environmental problems: the greenhouse effect, depletion of the ozone layer, acidification, eutrophication, and disposal of solid waste. The Dutch accounts differ from the Norwegian or the U.N. system in that they include several transformations of the information for interpretation in policy terms.

Taking as an example the concern about acidification, the NAMEA record the discharge in thousands of tons of each of the three major pollutants responsible for acidification; sulfur oxides, nitrogen oxides, and ammonia; by each sector of the economy, including households and net imports. Because any given amount of the three chemicals affects acidification differently, they are transformed into acidification equivalents. The transformation of acidification equivalents into deposition of acid-forming compounds is also recorded for different regions in the Netherlands and for exports. Finally, the interpretation of the discharge of pollutants that cause acidification is represented in the national accounts as the ratio between total acidification emissions (or total deposition) and the policy target for acidification emissions (or deposition). The Dutch do not intend to monetize the accounts.

These accounts are used to address many issues that the United Nations has identified, such as the environmental impact of trade or of agriculture, and to assess the economic and environmental effects of policies aimed at reducing pollution in various sectors, notably agriculture.

Botswana.[5] Botswana is the only African country to have attempted NRA. The country has constructed a preliminary set of NRA and plans to construct a full set to assist in preparing, implementing, and monitoring the National Development Plan and the National Conservation Strategy (Perrings et al. 1989). Botswana's economy depends heavily on its resource base: minerals provide the bulk of national income, livestock and meat exports are a significant part of the country's economy and cultural life, and wildlife tourism is also important. Crop agriculture is a significant activity for rural communities, but environmental conditions prevent Botswana from achieving food self-sufficiency. Competition for scarce water and land resources is intense among economic activities (livestock and agriculture) and other uses (wildlife, domestic water and fuelwood requirements, and industrial development).

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[5] Botswana is treated in more detail than the other countries in this section because of this paper's focus on relevance of NRA for Africa and because one of the authors was able to meet with government staff in Botswana to discuss the status and plans. (See Lange 1993 for a full report.)

The need to coordinate long-term, economic development strategies with those to use the resource base sustainably has been recognized widely; NRA are expected to play an important role in the coordination process. Currently, each ministry is responsible for the quantitative assessment of the resource requirements and the environmental effect of its development strategies; most analysis is conducted on a sector-by-sector basis, often on the medium-term, six-year cycles of National Development Plans. No process or framework is in place to ensure consistency among these microlevel plans in terms of their cumulative implications for the natural resources base. For example, objectives developed for detailed subsectors of agriculture, such as maize, sorghum, vegetables, forestry, and livestock can simultaneously assume the use of the same or overlapping land and water resources. The future of wildlife depends on habitat availability that cannot be assessed without knowing the implications for land use or future plans for livestock and agriculture. The dispersion of data collection and planning responsibilities among ministries and departments increases the likelihood of inconsistency. The NRA are expected to promote integration of analysis and decision-making.

Until now, studies to evaluate Botswana's long-term, economywide use of resources, such as the Water Master Plan, design and evaluate alternative strategies for a single resource at a time. Typically, economic activities require combinations of resources, and alternative development strategies involve trade-offs among resources, such as use of water and of different qualities of land in specific regions. Long-term strategies must evaluate the relative importance of these trade-offs among resources, which a single-resource approach to conservation and development cannot reveal.

NRA are intended to overcome these obstacles to planning for sustainable development. They will represent the use of multiple natural resources by all economic sectors and will be integrated with the I-O model of Botswana to provide a tool for both macroeconomic and microeconomic policy analysis. The macrolevel concern is for the rational, sustainable use of Botswana's natural resources. Data from the NRA will be used with an I-O model to ensure consistency among the various ministries' plans for each sector. Botswana's I-O model has been the core of the planning process for nearly two decades. At the microlevel, the data will be used for the design of sectoral policy, including the calculation of shadow prices (see Box D) to set policies about appropriate fees, subsidies, or taxes on the use of natural resources.

Box D

Shadow prices represent a set of hypothetical prices for goods or services for which market prices are distorted or not readily available, such as clean air or water. In contrast to accounting valuation techniques, which have no feedback on the rest of the economy, these prices are the outcome of a model in which potentially all variables can change.

Preliminary accounts have been constructed from existing data for water, minerals, livestock, food crops, and forests, including fuelwood. Resources are disaggregated according to several criteria; for example, livestock accounts include four types of animals, nine size classes

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of herds, and commercial and informal sectors. Accounts for water are constructed for each major river system (surface-water accounts) and region (ground-water accounts). Land-use accounts are planned and will include information on livestock and wildlife density, vegetative cover, and soil erosion.

While the need for and desirability of constructing NRA and integrating them into the planning process are widely acknowledged and much of the data are available, progress since the initial study has been slow. Botswana's experience illustrates some of the difficulties that can be encountered in moving from a pilot project to full institutionalization of natural resources accounting. Construction and use of NRA require effective leadership of an activity that cuts across ministries and professional disciplines. In Botswana, the National Conservation Strategy Agency (NCSA) was established to play that role. It has both advocacy and enforcement responsibilities (e.g., getting legislation passed and monitoring enforcement), as well as analytical responsibilities to design long-term, sustainable development strategies. The NRA were designated as the cornerstone of NCSA's analytical role. However, the NCSA has a shortage of trained staff (until recently, it was able to fill only three of the ten professional posts funded). Given these circumstances and the wide range of responsibilities, it chose to focus on legislative advocacy and enforcement responsibilities that have an immediate effect. The analytical work has been postponed until NCSA is able to recruit a full staff. Shortage of trained staff, an acute problem in most developing countries, will pose an obstacle to introducing management-oriented NRA.

Evaluation

Like the national income and product accounts, management-oriented NRA serve many purposes. NRA can be tabulated for an aggregate assessment of performance in a given year, or the data can be used with economic models for policy analysis and strategic planning. The management-oriented approach to NRA is more ambitious than the summary NRA in terms of implementation requirements but offers advantages in terms of policy relevance.

Successful integration of management-oriented NRA with economic models and their joint application to policy issues have been promising but slow. The reason, in part, is the relatively little experience on which practitioners can draw. Neither standardized definitions nor methods for collecting data about the environment exist. Standardization will come only through experience. Existing NRA represent significant contributions, but much work remains.

Design of NRA has generally been based on a recognized importance of the environment in economic analysis and an identification of critical natural and environmental resources. The notion that specific policy questions that might be addressed with the NRA need to be formulated as part of the design process is not yet generally recognized. The amount of information about the environment that could be collected is unlimited. Emphasis on the collection of data in the absence of well-defined objectives for their use can result in mismatching the types of data collected with the needs of policymakers. This has been the experience with some of the accounts in Norway and may be the cause of problems in compiling and using the accounts in

France. Lessons learned from existing management-oriented NRA are further explored in Section 4, which discusses how to improve them. To date, NRA have been successfully institutionalized in developed countries. The experience of Botswana indicates that the shortage of trained personnel is a serious obstacle to establishing NRA in developing countries, even where the need for integrated environmental-economic databases and policy tools is recognized.

4. Improving Natural Resource Accounts for Analysis

Experience with existing management-oriented NRA suggests principles for their successful construction and use. From their inception, NRA should be viewed as problem-driven and -defined, designed to address clearly defined environmental problems. Given the substantial commitment of human and financial resources required for these NRA and the paucity of experience with them, a sequential approach should be taken to their construction and use. Such an approach allows for feedback and modification during each stage to ensure that the data meet the needs of policymakers. Developing countries with little or poor-quality data face additional challenges. For some countries, construction of NRA may not be feasible or may not represent the best use of human and financial resources.

While developing countries share many commonalities in development objectives and environmental pressures, each case is unique for a wide range of physical, economic, and social reasons. Thus far, only two developed countries (Norway and the Netherlands) have had long-term, government-sponsored experience in constructing NRA. Of these, only Norway has made extensive use of them. In contrast, The Netherlands is a recent addition to the NRA community. This experience is particularly valuable because, while one-time or occasional accounts can make use of ad hoc sources and arrangements, maintenance of ongoing accounts requires standards and systematic methods that meet the needs of a wide range of potential users. Other countries have much to learn from this experience. Accounts for developing countries may need to differ significantly from those constructed in developed countries: the informal sectors of the economy should be included; accounts for natural resources like forests, land, water, and wildlife might take precedence over pollution problems; different ecological conditions within a country may require creating separate accounts for each relatively homogeneous geographic region or population group.

Potential Policy Applications

With the exception of the Netherlands, relatively little attention has been given to the design of physical indicators as part of the NRA. For example, the U.N. handbook describes several monetary valuation methods but does not discuss physical indicators even though some valuation methods depend on these. More attention needs to be paid to methods for developing physical standards to interpret the NRA in policy terms or to link existing standards with the NRA; such issues as interpretation and ranking of qualitative standards need to be addressed.

While NRA can be used for both monitoring and policy analysis, they have been used mostly for analysis. Policy analysis and decision-making occur on three levels that correspond to three relatively distinct levels of decision-making:

Field level. Policymaking at the field level deals with practical questions related to conducting a local-level activity that can best be answered in the field, like the use of sleds versus bulldozers to construct roads for logging or the height and location of windbreaks in a specific village.

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Sectoral level. Decisionmakers at the sectoral level are responsible for coordinating field-level activities within the sector. These decisions, which cannot be made at the field level, include allocation of quotas and concessions for forests or fisheries and setting stumpage and irrigation fees.

Economywide[6] */regional level.* This level of policymaking, unlike the other two, is multisectoral. Policymakers at this level are responsible for coordinating the activities and policies of all sectors and for weighing alternatives and trade-offs among sectors. At this level, a country's development budget is allocated among the ministries, trade policy is determined, and the relative importance of protecting resources critical to agriculture, forestry, fishery, minerals, and industry is determined.

Some overlap and feedback occur between levels, but it is clear, for example, that national trade policy cannot be made within a single village, and policy for the mining sector needs to involve the ministry of mining. Given the role of NRA in organizing multisectoral natural resources and economic information, they are particularly well-suited for economywide, regional, and sectoral levels of policy analysis. It is not surprising that all the policy applications of NRA have occurred at these levels.

Examples of potential NRA policy analysis were discussed in Section 3 (United Nations 1993 and CBO 1994). NRA, used with a simple I-O or CGE model with an I-O core, can identify the direct and indirect environmental effects of policies, and the cumulative, multisectoral, economywide effects. This analytic framework can also provide input for designing ways to deal with the problem.

In Africa, such a modeling framework can be useful in designing National Environmental Action Plans (NEAPs) and for monitoring and evaluating NEAPs as they are implemented. The design of such a national strategy relies on professionals from many disciplines to formulate strategy components. A comprehensive framework that coordinates and integrates the many various assumptions is useful at the design stage, during implementation, and for monitoring and evaluation, especially in cases of resources subject to competing demands, such as land. For example, a land-use planner and the staffs of different ministries (e.g., agriculture and livestock, forestry, and tourism/wildlife) can make projections about land use and its environmental impacts. These projections may not be consistent because each ministry's plans are made separately. NRA can provide a framework for coordinating and integrating these separate projections. A simple I-O model can reveal unexpected interrelations and pinpoint inevitable inconsistencies associated with alternative projections.

Any project that spans different sectors of the economy can also benefit from this

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[6] The term *economywide* is used rather than *macroeconomic* because the latter term suggests a highly aggregate analysis. Yet, this need not be the case; indeed, it often is not in economywide decision-making.

approach. For example, the USAID-sponsored Trade and Investment (TIP) Program in Ghana promotes nontraditional exports that cut across agriculture, forestry, and fisheries, as well as salt, wildlife, and tourism, with diverse effects on the rural population and environment. The TIP requires careful evaluation of the trade-offs between benefits, such as potentially higher export earnings, and costs, such as loss of food crops, displacement of the rural poor and migration to already overburdened urban areas, and many forms of potential environmental degradation. Typically, plans are developed and trade-offs evaluated for each proposed nontraditional export product separately. The analytical framework described here can evaluate the simultaneous, cumulative environmental effects of the TIP's components.

Sequential Approach to Construction and Use

Most countries have used national accounts for decades. Consequently, a good understanding exists about how to construct these accounts under a wide range of conditions. The interaction over this period between the individuals who construct the accounts and those who use them has been critical to the development of accounts useful for analytical purposes. In many instances this interaction has led to the accounts' revision. Where national accounts do not satisfy users' data needs, supplementary statistics can be collected.

Experience with NRA is more limited. NRA have been compiled for only a few countries and for a much shorter period of time. The use of NRA and the subsequent interaction between data compilers and data users is even more limited. Considerable uncertainty exists about how the accounts should be compiled and how they can be used; standards do not exist. Often, a wide gap exists between what data users would like and what accounts are able to provide. Many issues will be resolved only through experience in constructing and using the accounts. Because of these conditions and the cost of construction, NRA should be constructed sequentially. Each stage will improve understanding of the resource base and provide policymakers and practitioners the opportunity to offer feedback about the usefulness of the NRA, i.e., its classifications, definitions, levels of detail, and physical or value units. This work can be carried out in three stages:

1) The classification scheme for NRA in a given country should be designed based on predetermined analytical uses and alternative development strategies identified. A preliminary NRA is constructed for a given year, based mostly on existing data. Physical standards are established to assess the state of the environment in that year.

2) A more detailed, complete set of accounts is constructed through refining existing data and collecting additional data. A simple model is constructed and a few alternative development strategies are formulated for analysis with the model to demonstrate how the NRA can be used for policy analysis.

3) More detailed and realistic scenarios and an expanded modeling framework are built, making it possible to reach a wider range of policy conclusions. The expansion could include representation of additional resources and environmental variables, the partial

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monetization of environmental accounts, or any other feature important for natural resources management in a given country.

Each stage is designed to build on previous work, and data are collected such that, if revisions to classifications are found necessary in later stages, they are easily accomplished. The work plan for each stage will vary by country, depending on data availability, the nature of the environmental problems, or other conditions. The length of time required to complete each stage can also vary. Additional work will be required in a country where the economic database is weak or limited.

Construction for Countries with Limited Data

For a developing country, Botswana has relatively abundant data; several I-O tables and SAMs have been compiled. Data about many natural resources are available. Even with relatively good data, however, construction of NRA for Botswana has proceeded slowly. The construction and use of NRA will be more time-consuming in countries with poorer data.

Most countries have institutionalized the framework of the SNA for economic data within official statistical agencies even if they collect little data. This occurs because the framework represents more than just a repository for data. As a comprehensive and systematic description of the relations among economic sectors, the framework provides a means of organizing information in a way that informs policy, identifying data that are needed, and prioritizing data collection.

Similarly, it is useful to establish a framework for NRA in which environmental data can be organized systematically and related to economic data. In many countries, more data may exist than is assumed. Different government ministries or agencies often collect information for some sectors of the economy, usually those most dependent on the natural environment, such as agriculture and forestry. These data may not find their way to central statistical agencies but are invaluable for constructing NRA. The challenge in constructing a set of accounts may be primarily locating and integrating existing data rather than collecting new data.

SAMs, which can be used as the basis of an economic model, have been constructed for various African countries and, in many cases, can provide sufficiently detailed information about economic activities for a reasonable analysis. Not all sectors need be represented in detail. For example, agriculture, livestock, or forestry can be disaggregated while only one or two sectors represent the rest of the economy. A preliminary analysis can help set priorities for improving the database.

Given the limited availability of data in many African countries and the importance of the spatial dimension of many environmental problems, the initial objective may be to construct a set of accounts that can be used with a simple economic model to investigate a regional problem rather than a complete set of accounts at the national level. It must be recognized, of course, that construction of NRA may not be presently feasible or useful in some countries.

5. Natural Resource Accounts for Africa

The need to include data about the environment in economic analysis is obvious. Much work is underway to integrate environmental and economic analysis, including the implementation of NRA. The U.N. handbook of NRA to be constructed as satellite accounts to the SNA represents an international consensus that natural resources accounting is useful and accepted. Like the national accounts, however, NRA can be constructed at different levels of detail for different purposes.

Range of Options and Recommendations

In deciding whether to construct NRA and what type, the first issue to address is the purpose for the accounts. For reasons discussed in Section 2, fully monetized, summary NRA to calculate EDP are highly problematic, especially in African countries where nonmarketed natural resources are likely important. Problems resulting from the often poor quality and unreliability of reported GDP and the omission of informal-sector activities are also likely to be especially severe in many African countries. Even if an improved indicator of sustainability is desired, EDP will probably not prove useful.

If, however, the purpose of NRA is to monitor the state of the environment and economy and to improve policymaking and the management of natural resources, the management-oriented NRA, like those constructed for Norway, the Netherlands, the Philippines, and Botswana, could be useful. Construction and use of such NRA would require a substantial commitment of human and financial resources. Section 4 described how management-oriented NRA can be constructed and used sequentially. These NRA, coupled with a simple I-O or SAM-based model, can provide a powerful tool for evaluating the trade-offs among development strategies.

Not every African country has the economic or environmental data to construct NRA easily or the capability to use the NRA effectively once they are compiled. In fact, effective use of NRA to address policy issues may be an even greater challenge than compiling the NRA. Even in a country with small and weak existing data, however, studies of particular problems (e.g., water availability) can benefit from being conceived within a NRA-SNA framework that stresses common classifications, cumulative methodology, and an economywide perspective. Data compiled for such a specialized study can, in turn, become the nucleus for a broader, subsequent survey. Thus, management-oriented NRA is both a process and a product.

There are no hard and fast rules that can be used to determine when it is worthwhile for a country to construct NRA. Based on experience with NRA throughout the world, however, three elements can be identified that are essential for successful construction and use of NRA:

- *Clearly defined policy applications*: To ensure that decisionmakers use the NRA, the problems NRA will address need to be identified from the outset. NRA need to be demand-driven to avoid becoming just an "accounting exercise." Since the strength of

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NRA for policy analysis is that the framework includes a range of natural resource variables and environmental impacts across multiple sectors, it is most useful when addressing development alternatives that require coordination among different sectors competing for scarce resources, such as livestock, agriculture, forestry, and wildlife management. It is not necessary to construct NRA to address problems concerning a single issue or single sector.

- *Technical feasibility*: Some environmental and natural resource data as well as economic data should be available, though initially these data need not be collected by a central statistics office. A great deal of information is already available for many countries, albeit scattered in various ministries and in case studies or project documents. While the quality of the data can vary considerably, it is often adequate for policy analysis.

- *Institutional capability*: The construction and use of NRA cuts across ministries and professional disciplines. It is crucial to identify a ministry that can provide effective leadership in coordinating interministerial participation.

A successful NRA project can be implemented even if the initial technical feasibility and institutional capability are not strong, if there is a commitment to building that capability.

Institutionalizing Construction and Use

The compilation of summary NRA has generally been a one-time effort and has not yet been integrated into the regular, ongoing activities of a country's statistical office. In contrast, a number of the management-oriented NRA are part of the regular data collection activities of government agencies, although they are not necessarily produced on an annual basis. In Norway, NRA are compiled every three years; the Netherlands plans to compile NRA annually. The United Nations (Bartelmus and van Tongeren 1994) recommends constructing a full set of detailed accounts every five to ten years, like the I-O tables and SAMs. Abbreviated accounts can be compiled annually and later revised on the basis of the detailed accounts just as national income accounts are revised by periodic construction of I-O tables. Special studies can be conducted periodically to address different issues.

At the outset of any NRA effort, it is important to consider how to institutionalize the capability to compile and use NRA in the host country. The first NRA efforts in Indonesia and Costa Rica were useful to illustrate the importance of NRA, but those exercises did not represent an adequate model for future work since they did not build domestic capacity to continue the work beyond the initial study. Building such capability requires that individuals be familiar with policy design, collecting data, and building models for analyzing data; they must also possess various technical skills often lacking in many developing countries. The policy community must also commit resources to build this capability, which is likely a long-term process. The first step is a feasibility study demonstrating the usefulness of this approach to NRA. Involving host-country professionals in the early stages is a critical requirement.

REFERENCES

Alfsen, K. 1991. *Use of macroeconomic models in analysis of environmental problems in Norway and consequences for environmental statistics.* Working Paper No. 61. Oslo: Central Bureau of Statistics of Norway.

_____. 1994. Natural resource accounting and analysis in Norway. Paper accepted for presentation at the Third Biennial Conference of the International Society of Ecological Economics, October 24-28, San Jose: Costa Rica.

Alfsen, K., T. Bye, and L. Lorentson. 1987. *Natural resource accounting and analysis, the Norwegian experience, 1978-1986.* Oslo: Central Bureau of Statistics of Norway.

Barbier, E. and A. Markandya. 1990. The conditions for achieving environmentally sustainable development. *European Economic Review* 34:659-69.

Bartelmus, P., E. Lutz, and S. Schweinfest. 1992. *Integrated environmental and economic accounting: A case study for Papua-New Guinea.* World Bank Environmental Working Paper No. 54. Washington, D.C.: The World Bank.

Bartelmus, P. and J. van Tongeren. 1994. Environmental accounting: an operational perspective. U.N. Department for Economic and Social Information and Policy Analysis, Working Paper Series No. 1.

CBO. 1994. Greening the national accounts. Washington, D.C.: Congressional Budget Office.

Central Bureau of Statistics of Norway. 1992. *Natural resources and the environment 1991.* Oslo: Central Bureau of Statistics of Norway.

Commission for Environmental Accounting. 1991. Taking nature into account: Proposed scheme of resource and environmental accounting. Stockholm: Swedish Government Official Reports.

Daly, H. 1989. Toward a measure of sustainable net national product. In *Environmental accounting for sustainable development*, eds. Y.J. Ahmad, S. El Serafy, and E. Lutz. Washington, D.C.: The World Bank.

_____. 1991. Elements of environmental macroeconomics. In *Ecological economics: The science and management of sustainability*, ed. R. Costanza. New York: Columbia University Press.

de Haan, M., S. Keuning, and P. Bosch. 1993. Integrating indicators in a national accounting matrix including environmental accounts (NAMEA). Netherlands Central Bureau of Statistics, No. NA-060.

Duchin, F., G. Lange, and G. Kell. forthcoming. Some issues relating trade, technology, and the environment and their implications for developing countries. *Journal of Ecological Economics.*

Eisner, R. 1988. Extended accounts for national income and product. *Journal of Economic Literature* 26(4):1611-84.

El Serafy, S. 1989. The proper calculation of income from depletable natural resources. In *Environmental accounting for sustainable development*, ed. Y.J. Ahmad, S. El Serafy, and E. Lutz. Washington, D.C.: The World Bank.

_____. 1991. The environment as capital. In *Ecological economics: The science and management of sustainability*, ed. R. Costanza. New York: Columbia University Press.

_____. 1993. *Country macroeconomic work and natural resources.* World Bank Environmental Working Paper No. 58. Washington, D.C.: The World Bank.

EEC. 1992. *Towards sustainability: A European community programme of policy and action in relation to the environment and sustainable development.* Brussels: European Economic Commission.

Goodwin, N. 1991. *Social economics: An alternative theory.* New York: St. Martin's Press.

Hartwick, J.M. 1977. Intergenerational equity and the investing of rents from exhaustible resources. *American Economic Review* 67(5): 972-74.

Keuning, S. 1992. National accounts and the environment: The case for a systems approach. Internal report for the National Accounts Research Division, Central Bureau of Statistics, The Netherlands.

_____. 1993. An information system for environmental indicators in relation to the national accounts. In *The value added of national accounting*, eds. W. de Vries, G. den Bakker, M. Gircour, S. Keuning, and A. Lenson. Voorburg: Netherlands Central Bureau of Statistics.

Lange, G. 1993. Assessment of natural resource accounting in Botswana. Trip report, July 23-August 6, 1993, for USAID Bureau for Africa, ARTS/FARA.

Mäler, K.G. 1991. National accounts and environmental resources. *Environmental and Resource Economics* 1(1): 1-15.

~~Moss, M., ed. 1973. *The measurement of economic and social performance.* Studies in Income and Wealth, Vol. 38.~~ New York: Columbia University Press.

Myers, N. 1988. *Natural resource systems and human exploitation systems: Physiobiotic and ecological linkages.* World

46

Bank Environment Department Working Paper No. 12. Washington, D.C.: The World Bank.

Natural Resources Accounting Project. 1991. The Philippines Natural Resources Accounting Project: Executive Summary. Report for Philippines Department of Environment and Natural Resources and USAID. December.

_____. 1993. The Philippines Environmental and Natural Resources Accounting Project: Phase II Project Brochure and Work Plan. Information Series No. 1.

Nordhaus, W.D. and J. Tobin. 1973. Is growth obsolete? In *The measurement of economic and social performance*, ed. M. Moss. New York: Columbia University Press.

OECD. 1989. *Environmental policy benefits: Monetary valuation*. Paris: Organization for Economic Co-operation and Development.

Pearce, D., A. Markandya, and E. Barbier. 1989. *Blueprint for a green economy*. London: Earthscan Publications.

Perrings, C., A. Gilbert, D. Pearce, and A. Harrison. 1989. *Natural resource accounts for Botswana: Environmental accounting for a natural resource-based economy*. LEEC Paper 89-11. London: London Environmental Economics Centre.

Peskin, H. 1991. Alternative environmental and resource accounting approaches. In *Ecological economics: The science and management of sustainability*, ed. R. Costanza. New York: Columbia University Press.

_____. 1993. The contribution of resource and environmental accounting to policy formulation in the developing countries of Africa. Paper prepared for USAID's Environmental and Natural Resource Policy and Training Project.

Peskin, H. with E. Lutz. 1990. *A survey of resource and environmental accounting in industrialized countries*. World Bank Environment Department Working Paper No. 37. Washington, D.C.: The World Bank.

Pezzey, J. 1989. *Economic analysis of sustainable growth and sustainable development*. World Bank Environment Department Working Paper No. 15. Washington, D.C.: The World Bank.

Repetto, R., W. B. Magrath, M. Wells, C. Beer, and F. Rossini. 1989. *Wasting assets: Natural resources in the national income accounts*. Washington, D.C.: World Resources Institute.

Sagoff, M. 1988. *The economy of the Earth*. Cambridge, England: Cambridge University Press.

Schafer, D. and C. Stahmer. 1989. Input-output model for the analysis of environmental protection activities. *Economic Systems Research* 1(2): 203-28.

Solow, R. 1974. Intergenerational equity and exhaustible resources. *Review of Economic Studies*. 62(1): 29-36.

_____. 1992. An almost practical step toward sustainability. Paper presented at Resources for the Future, October.

Stirling, Andrew. 1992. Regulating the electricity supply industry by valuing environmental effects. *Futures* 24(10): 1024-47.

Tropical Science Center and World Resources Institute. 1991. *Accounts overdue: Natural resource depreciation in Costa Rica*. Washington, D.C.: World Resources Institute.

U.N. 1992. U.N. handbook on integrated environmental and economic accounting. Draft.

_____. 1993. *Integrated environmental and economic accounting, interim version*. Studies in Methods, Handbook of National Accounting, Series F, No. 61. New York: United Nations.

U.S. Environmental Protection Agency. 1992. Environmental and resource accounting in the Chesapeake Bay Region. Unpublished draft.

Uno, K. 1990. National accounting and the environment. Paper presented at the United Nations University, WIDER Project on the Environment and Emerging Development Issues, Helsinki, September 3-7.

_____. 1991. Quality-of-life and environmental accounting: Assessment of pollution prevention investment. Paper presented at the International Association for Research in Income and Wealth, Conference on Environmental Accounting, Baden, May 27-29.

van Tongeren, J., S. Schweinfest, and E. Lutz. 1991. *Integrated environmental and economic accounting: A case study of Mexico*. World Bank Environmental Working Paper No. 50. Washington, D.C.: The World Bank.

SELECTED BIBLIOGRAPHY

Ahmad, Y.J., S. El Serafy, and E. Lutz, eds. 1989. *Environmental accounting for sustainable development*. Washington, D.C.: The World Bank.

Barbier, E. 1992. Natural capital and the economics of environment and development. Paper presented at a conference, International Society of Ecological Economics, August 3-6, Stockholm.

Bartelmus, P. 1991. Environmental accounting and statistics. *Natural Resources Forum* 1(2):77-84.

_____. forthcoming. Accounting for sustainable growth and development. *Structural Change and Economic Dynamics*.

Bartelmus, P., C. Stahmer, and J. van Tongeren. 1991. Integrated environmental and economic accounting: Framework for a SNA satellite system. *Review of Income and Wealth* 37(2):111-48.

Bergman, L,. D.W. Jorgenson, and E. Zalai. 1990. *General equilibrium modeling and economic policy analysis*. Oxford and Cambridge, Massachusetts: Basil Blackwell, Inc.

Brown, P.G. 1992. The failure of market failures. *Journal of Socio-Economics* 1:1-24.

Cleaver, K. and G. Schreiber. 1992. *The population, agriculture and environment nexus in sub-Saharan Africa*. Washington, D.C.: The World Bank.

Costanza, R., ed. 1991. *Ecological economics: The science and management of sustainability*. New York: Columbia University Press.

da Motta, R. and C. Young. 1991. Natural resources and national accounts: Sustainable income from mineral extraction in Brazil. Unpublished paper.

de Boo, B., P. Bosch, C. Gorter, and S. Keuning. 1991. An environmental module and the complete system of national accounts. Paper presented at the Conference on Environmental Accounting, International Association for Research in Income and Wealth, May 27-29, Baden, Germany.

Denison, E.F. 1971. Welfare measurement and the GNP. *Survey of Current Business* 51(1):13-16.

Gammage, S. 1990. Natural resource accounting. *Environmental economics in the developing world*. Vol. 2. London: London Environmental Economics Centre.

Gilbert, A.J. and W.A. Hafkamp. 1986. Natural resource accounting in a multi-objective context. *The Annals of Regional Science* XX(3):10-37.

Goodland, R., H. Daly, and S. El Serafy, eds. 1992. *Population, technology, and lifestyle*. Washington, D.C.: Island Press.

Hamilton, K.E. 1991. Organizing principles for environmental statistics. Ottawa: Statistics Canada.

Hartwick, J.M. 1990. Natural resources, national accounting and economic depreciation. *Journal of Public Economics* 43(3):291-304.

_____. 1991. Degradation of environmental capital and national accounting procedures. *European Economic Review* 35(2/3):642-49.

Hecht, J. and H. Peskin. 1992. Natural resource accounting in the developing world: A neo-classical approach. Paper presented at the workshop Environmental and Natural Resource Accounting, United Nations Environment Programme, February, Nairobi, Kenya.

Herfindahl, O. and A. Kneese. 1973. Measuring social and economic change: Benefits and costs of environmental pollution. In *The measurement of economic and social performance*, ed. M. Moss. Studies in Income and Wealth, Vol. 38. New York: Columbia University Press.

Hueting, R. 1991. Correcting national income for environmental losses: A practical solution for a theoretical dilemma. In *Ecological economics: The science and management of sustainability*, ed. R. Costanza. New York: Columbia University Press.

Hueting, R., P. Bosch, and B. de Boo. 1992. *Methodology for the calculation of sustainable income*. Gland, Switzerland: World Wide Fund for Nature.

Institut National del la Statistique et des Etudes Economiques. 1986. *Les comptes du patrimonie naturel*. Paris: INSEE.

Jaszi, G. 1973. A framework for the measurement of economic and social performance: Comment. In *The measurement of economic and social performance*, ed. M. Moss. Studies in Income and Wealth, Vol. 38. New York: Columbia

University Press.

Juster, F.T., P.N. Courant, and G.K. Dow. 1981. A theoretical framework for the measurement of well-being. *Review of Income and Wealth* 21(1):1-32.

Levin, J. 1990. The economy and the environment: revising the national accounts. *IMF Survey* 19(11):161-69.

_____. 1991. Valuation and treatment of depletable resources in the national accounts. IMF Working Paper No. 91/73. Washington, D.C.: International Monetary Fund.

Magrath, W. and P. Arens. 1989. *The costs of soil erosion on Java: A natural resource accounting approach.* World Bank Environment Department Working Paper No. 18. Washington, D.C.: The World Bank.

Norgaard, R.B. 1989. Three dilemmas of environmental accounting. *Ecological Economics* 1(3):303-14.

Pearce, D., A. Markandya, and E. Barbier. 1990. *Sustainable development: Economics and environment in the Third World.* London: Edward Elgar.

Pearce, D. A. and R. K. Turner. 1990. *Economics of natural resources and the environment.* Hertfordshire, England: Harvester Wheatsheaf.

Peskin, H. 1989. *Accounting for natural resource depletion and degradation in developing countries.* World Bank Environment Department Working Paper No. 13. Washington, D.C.: The World Bank.

Peskin, H., W. Floor, and D. Barnes. 1992. *Accounting for traditional fuel production: The household energy sector and its implications for the development process.* World Bank Industry and Energy Department Working Paper No. 49. Washington, D.C.: The World Bank.

Peskin, H. and J. Peskin. 1989. The valuation of non-market activities in income accounting. *Review of Income and Wealth* 24(1):71-91.

Solow, R. 1986. On the intertemporal allocation of natural resources. *Scandinavian Journal of Economics* 88(2):141-49.

Theys, Jacques. 1989. Environmental accounting in development policy: The French experience. In *Environmental accounting for sustainable development*, eds. Y.J. Ahmad, S. El Sarafy, and E. Lutz. Washington, D.C.: The World Bank.

Tiezzi, E., N. Marchettini, and S. Ulgiati. 1991. Integrated agro-industrial ecosystems: An assessment of the sustainability of a cogenerative approach to food, energy, and chemicals production by photosynthesis. In *Ecological economics: The science and management of sustainability*, ed. R. Costanza. New York: Columbia University Press.

U.N. 1984. *A framework for the development of environment statistics.* Statistical Papers, Series M, No. 78. New York: The United Nations.

_____. 1988. *Concepts and methods of environment statistics and human settlements statistics.* Studies in Methods, Series F, No. 51. New York: The United Nations.

_____. 1991. *Concepts and methods of environment statistics of the natural environment.* Studies in Methods, Series F, No. 57. New York: The United Nations..

Uno, K. 1989. Economic growth and environmental change in Japan--net national welfare and beyond. In *Economy and ecology: Towards sustainable development*, eds. F. Archibugi and P. Nijkamp. Boston: Kluwer Academic Publishers.

Weber, J.L. 1991. Natural patrimony accounting and integration of environmental statistics. Paper presented at the Conference on Environmental Accounting, International Association for Research in Income and Wealth, May 27-29, Baden.

World Bank. 1992. *World development report 1992.* New York: Oxford University Press.