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Green National Accounts: Policy Uses and Empirical Experience

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Green National Accounts: Policy Uses and Empirical Experience

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1 Introduction

Over the past 25 years the breadth of environmental and natural resource policy-making has expanded from dealing with pollution incidents, such as the grounding of an oil tanker, to grappling with the new complexities of achieving 'sustainable development' and protecting the global commons. Governments everywhere have committed themselves to these new goals, whether as a product of the United Nations Conference on Environment and Development in 1992, or in response to the report of the Brundtland Commission in 1987. As a result, policy makers need new measures of progress.

There has been corresponding innovation in information systems to guide resource and environmental policies, from the collection of physical and economic data to the development of conceptual frameworks. The OECD's 'Pressure-State-Response' framework, for instance, provides the means to interrelate complex information concerning human activities and the environment. Environmental performance indicators have taken on a key role in many countries. And natural resource and environmental accounts, with their coupling to *economic* accounts and indicators, promise to provide policy makers with measures of progress towards environmentally sustainable development.

The development of environmental and natural resource economics has highlighted the critical role that policy failure and market

failure play in the degradation of the environment. This has put the focus squarely on policy, where it belongs. Policy failures come in many forms, from inadequate property rights regimes, to under-pricing of natural resources, to subsidies on energy, fertilizers and pesticides that lead to negative impacts on the environment. Market failure exists wherever economic activities impose costs on others, in the form of pollutants carried downwind or downstream for instance, without any mechanisms for remediation.

Market failure is the prime reason that many analysts question the policy signals provided by our traditional economic indicators, in particular the Gross National Product (GNP). As codified in the UN System of National Accounts (SNA), GNP measures the sum total of economic production on the basis of transactions in the marketplace. As a result, GNP masks the depletion of natural resources and presents an incomplete picture of the costs imposed by the polluting byproducts of economic activity. This has led many people to conclude, as in the case of Robert Repetto, that:

This difference in the treatment of natural resources and other tangible assets [in the existing national accounts] reinforces the false dichotomy between the economy and 'the environment' that leads policy makers to

ignore or destroy the latter in the name of economic development¹.

The new emphasis that governments have placed on sustainable development is another source of criticisms of the traditional national accounts. Measures such as Net National Product (NNP) and National Income, while better than GNP for measuring sustainability, account only for the depreciation of produced assets, ignoring the value of depletion of natural resources and degradation of the environment. They cannot serve, therefore, as guides for policies aimed at achieving sustainable development. 'Greener' aggregates, it is hoped, can.

In addition to these criticisms of traditional national accounting aggregates, natural resource and environmental accounting has many other antecedents. The experience of the 'oil crisis' in the 1970's led to a concern with the physical scarcity of natural resources - the construction of natural resource accounts detailing the changing stocks and flows of physical quantities of resources was the result². Worries about the toxic effects of pollutants led to increasing interest in understanding the pathways that particular materials take through the economic system, with the development of material balance accounts being one of the responses³. And the desire to analyze the connection between economic activity and pollutant flows produced models linking Input/Output tables to accounts of pollution emissions⁴. All of these roots are still evident in what is broadly termed resource and environmental accounting.

The United Nations has recently attempted to bring some order to this field with the publication of interim guidelines on an integrated System of Environmental and Economic Accounts (SEEA)⁵. This system aims to provide a common framework within which greener national accounting aggregates, natural resource accounts and pollution flow accounts have their appointed places.

For developing countries, the adjustments to standard national accounting aggregates that result from resource and environmental accounting can be sizable. This is obviously true for the most resource-dependent economies, but it is also likely to be of growing importance for those countries that are rapidly industrializing and urbanizing - for these countries the growth in damages from pollution emissions, in terms of human health in particular, is of mounting concern.

Because of the strong potential for resource and environmental accounting to influence policies in developing countries, the World Bank has been an active participant in efforts to 'green' the accounts - part of this intellectual journey is described in the next section of this report. In 1995 the Bank published *Monitoring Environmental Progress*, which presented crude preliminary estimates of the rates of 'genuine' saving (accounting for resource depletion and environmental degradation) and total wealth for a wide range of countries. Efforts are now underway to carry out country-level case studies and to introduce green accounting aggregates more widely into the work of the Bank.

There is by now considerable empirical experience in the construction of a variety of resource and environmental accounts. One of the goals of this report is to critically examine the potential policy uses of the different varieties of accounts, in particular greener

¹ Repetto *et al.* (1993, p3).

² Alfsen (1993).

³ Ayres and Kneese (1969).

⁴ Leontief (1970) and Victor (1972).

⁵ United Nations (1993b).

national accounting aggregates such as genuine savings and 'Eco-Domestic Product.' The second goal is to describe and assess the range of experience that has been published

for both developed and developing countries. Before proceeding with this, the next section provides some background on national accounting and the SEEA.

2 Background on National Accounting and the SEEA

After the second world war, rebuilding shattered economies and forging economic growth were the main economic objectives for most countries. The System of National Accounts (SNA) was developed around that time, and not surprisingly, it focused exclusively upon measuring economic growth and in particular production in markets for which prices are available. Most people saw no need for better treatment of natural resources and the environment at that time; resources were considered abundant and the environment as an inexhaustible sink. Since then, however, the world population and the world economy have grown tremendously, which has put a stress on the natural environment. The need to consider natural capital has therefore gained broad acceptance, as has the realization that development encompasses the human and social dimensions as well.

The 1968 SNA guidelines, which were valid until 1993, considered depreciation of produced capital but did not deal with natural capital and its linkages with the economic system. During the 1980s, five UNEP-World Bank workshops were held to discuss the shortcomings of the SNA and possible remedies, with the results published in 1989.⁶ In the early 1990s, the United

Nations Statistical Office (UNSTAT) developed a framework for preparing a System of integrated Environmental and Economic Accounts (SEEA). A preliminary version of the framework was tested in Mexico and Papua New Guinea. Both the main elements of the SEEA and the case studies (as well as other conceptual and applied work) were published in the form of an UNSTAT-World Bank Symposium⁷. With the UNSTAT framework, an Eco-Domestic Product (EDP) can be calculated as follows: depreciation of produced assets is estimated and subtracted from GDP to arrive at an NDP; then estimates for depletion of natural resources and degradation of the environment are made and subtracted from NDP to arrive at EDP.

In Agenda 21, a key document emerging from the Rio Summit in 1992, it was recommended that integrated environmental and economic accounting be undertaken by the governments of the signatory countries. Such work would provide these governments with a set of supplementary indicators and would encourage the collection of relevant information and compilation in the area of natural resources and the environment.

⁶ Ahmad *et al.* (1989).

⁷ Lutz (1993).

The 1993 revision of the SNA. Under the general guidance of the Intersecretariat Working Group on National Income Accounts (consisting of the Commission of the European Communities, OECD, UNSTAT, the IMF, and the Bank), expert meetings were held from the mid-1980s to the early 1990s to address various issues in national accounting. From the environmental perspective, the two most significant changes introduced in the 1993 SNA were:

1. A more comprehensive view as to what constitutes an asset - all assets that contribute to marketable production are included. Such assets include land, subsoil resources, cultivated plants and livestock, and noncultivated natural assets that yield products such as timber. Where harvests exceed a sustainable yield, and where therefore stocks are being drawn down, the excess is subtracted from current income.
2. A recommendation that integrated environmental and economic accounting should be done in *satellite* (i.e. supplementary) *accounts* that are linked with the main (or 'core') accounts of the SNA. A full integration of integrated environmental and economic accounting into the main accounts was not considered feasible because of the limited case study work that had been done up to that time and because of outstanding conceptual and valuation issues.

Integrated Environmental Accounts. The United Nations Statistical Division (UNSD) has developed a Handbook on Integrated Environmental and Economic Accounting, which was published in tandem with the new SNA in 1993 and which outlines how integrated accounts are to be prepared. It is called an 'interim version' - i.e. once more

experience has been gained and a greater consensus achieved on issues such as valuation, a revised document will be issued. In addition, UNSD is currently working on a manual that is to assist countries with practical step-by-step guidelines on how to do integrated environmental and economic accounting.

Satellite accounts try to integrate environmental data sets with existing national accounts information, while maintaining SNA concepts and principles as far as possible. Environmental costs, benefits and natural resource assets, as well as expenditures for environmental protection, are presented in flow accounts and balance sheets in a consistent manner. That way the accounting identities of the SNA are maintained. One of the values of the SEEA framework compared to more partial approaches is that it permits balancing, so that rough monetary estimates can be made for residual categories.

A major difference between the SNA and the SEEA is that the latter has a more detailed asset classification, and that more estimates and imputations are made in near-market or non-market areas (for depletion and degradation), whereas the SNA continues to concentrate on income and assets that can be valued based on market price information.

Naturally, there are a number of outstanding conceptual and empirical issues. This should not be surprising, given that it took many years to develop the current system of national accounts, for which (market) data tends to be easily available, whereas for natural resources and the environment the physical information tends to be sketchy and the valuation issues difficult.

3 Policy Uses of Resource and Environmental Accounts

Having committed themselves to achieving sustainable development, governments face a number of challenges beyond the traditional concerns of natural resource and environmental ministries. Chief among these is achieving closer integration between economic policies and policies for the management of natural resources and the environment. A key message from the Brundtland Commission report is that current economic development policies may compromise the ability of future generations to enjoy sustained levels of well-being.

The need for integration of policies is reinforced by the experience of many countries that have adopted National Environmental Action Plans (NEAPs) or 'Green Plans' aimed at providing an overall policy framework for the environment⁸. Typically, these policy frameworks read as if they were written *by* the resource and environmental ministries *for* the resource and environmental ministries, with no links to the interests of economic ministries such as finance and planning.

⁸ The World Bank requires that NEAPs be established for all International Development Association (IDA) borrowers, as a condition for access to this concessional finance. In developed countries, the Netherlands and Canada were among the 'early adopters' of Green Plans.

These three players in government policy, the economic, the resource sector and the environmental ministries, all have a role in achieving sustainable development. Unfortunately, all three have generally had narrow views of their roles and a full integration or even communication has often been lacking.

At the most macro level, the planning ministry is concerned with the savings-investment gap, and the supply of foreign finance to fill this gap. This relates directly to one of the traditional concerns of the finance ministry, the external balance and its sustainability. The other typical concern at the ministry of finance is the fiscal deficit, and whether government borrowing⁹ is sustainable. The finance ministry is charged with achieving economic growth, but does not have the tools to determine whether current growth is being bought at the expense of future well-being. Resource ministries are often only concerned with promoting the exploitation of natural resources, while environmental ministries have responsibilities for conservation and environmental protection, but have generally had difficulty establishing priorities.

⁹ And/or monetary policy, if the fiscal deficit is financed by printing money.

Resource and environmental accounting cannot solve institutional problems, but it can provide the informational basis for better integration of economic, natural resource and environmental policies. The valuation exercises that underlie monetized environmental accounts can be of direct benefit in priority-setting. Monetized environmental accounts can provide high-level indicators of sustainable development. And both monetized and physical environmental accounts can support policy models that depict the broad environmental consequences of different economic strategies as well as the economic consequences of resource and environmental policies.

This section aims to explore the potential policy uses of resource and environmental accounting. As noted in the Introduction, there are several different flavors or approaches to environmental accounting. While many taxonomies are possible, the breakdown that most closely matches what countries are actually doing is the following:

- *adjusted national accounting aggregates*, such as EDP or expanded measures of saving and wealth;
- *natural resource accounts*, where the emphasis is on balance sheet items - the opening and closing stocks of various natural resources - and the flows that add to and subtract from the balance sheet position; these accounts are in quantities and (possibly) values, and may or may not be linked to the SNA through the National Balance Sheet Accounts;
- *resource and pollutant flow accounts* that embody considerable sectoral detail and often are explicitly linked to the Input-Output Accounts, a part of the SNA;
- and *environmental expenditure accounts*, which represent a breakout of existing figures in the SNA.

The potential and prospective uses of these different categories of accounts are presented below. The first two sections are devoted to alternative national accounting aggregates.

National Accounting Aggregates (1): Genuine Saving

Savings and investment play a central role in the economics of development, but the traditional measures in the national accounts ignore depletion of environmental assets. To correct this, *genuine saving* is defined as net saving less the value of resource depletion and the value of environmental degradation¹⁰. The policy implications of measuring genuine saving are quite direct: *sustained negative genuine savings must lead, eventually, to declining welfare*. Moreover, the consideration of the determinants of genuine saving provides an essential linkage between the interests of ministries of natural resources, environment, finance, and planning.

Figure 1 provides an example calculation of the rate of genuine saving in Pakistan. The underlying accounting is straightforward: gross saving equals gross investment less foreign borrowing, while net saving subtracts the value of depreciation of produced assets; the two genuine savings measures deduct the depletion of natural resources and the value of degradation of the environment (in this case soil erosion and health damages attributable to pollution) in succession.

From the policy-maker's perspective, the interesting question concerns what policies affect the levels of the individual curves. The gross saving curve anchors all others, in the sense that the macroeconomic policies that affect savings effort will shift all the other

¹⁰ Cf. Pearce and Atkinson (1993); Hamilton (1994); World Bank (1995).

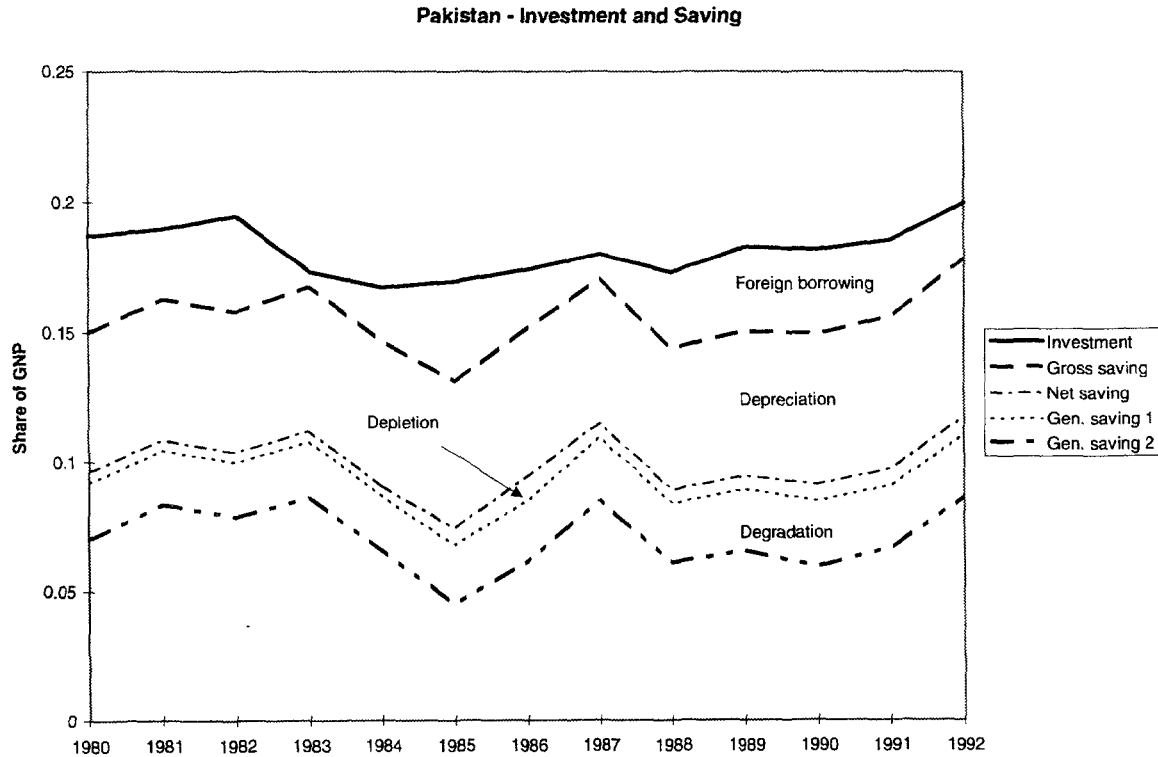


Figure 1. Source: authors' calculations, based on Brandon (1996).

curves upward or downward. The level of foreign borrowing then determines gross investment. Depreciation of assets is largely a physical phenomenon, representing the value of ordinary wear and tear on the stock of produced capital, and so is not altered by policy. Policies concerning natural resource exploitation and environmental management then affect the size of the remaining deductions.

What follows is a closer look at the policy issues that are raised by the analysis of genuine savings, beginning with the determinants of saving effort.

The gross savings rate in any country is determined by a whole range of micro- and macroeconomic policies that affect savings behavior by individuals and institutions. In seeking to alter rates of saving, the questions for the policy-maker include:

- Is the level of government current expenditure appropriate and sustainable? Dissaving by the government sector depresses the aggregate saving rate.
- Does the tax system penalize or encourage saving? Consumption taxes, income taxes and payroll taxes all have different incentive effects for savers.
- Does monetary policy set positive real interest rates? Negative real interest rates are an obvious disincentive to save.
- Do government policies support a viable financial sector? This affects both incentives to save and the efficiency with which savings are channeled into investments.

The point in all of this is not that an environmental economist in the ministry of environment should be dictating macroeconomic policies to the ministry of finance.

Rather, if the rate of genuine saving is deemed to be too low - negative rates being the obvious example - then the starting point is necessarily the macroeconomic determinants of total savings effort.

Next, one of the key determinants of genuine savings rates for developing countries is the value of resource depletion. It is obviously incorrect to conclude that genuine savings should be boosted by restricting resource exploitation. One of the key lessons from growth theory¹¹ is that the discovery of a natural resource, properly managed, leads to a permanent increase in the sustainable stream of income for a country. The policy question with regard to natural resources is therefore what constitutes 'proper management.' Clearly, the important concern is the achievement of efficient levels of resource exploitation. The policy considerations are therefore:

- Do tenurial regimes encourage sustainable exploitation? Open access to living resources generally leads to their depletion.
- Are royalties set correctly, to capture resource rents while leaving the exploiting firms with adequate rates of return?

An important element of the proper management of the resource endowment is to ensure that royalties on natural resource exploitation are invested in other productive assets - it is this rather simple concept of 'preserving total capital' that is captured by genuine savings measures. Basic questions for countries with natural resources are:

- Are the royalties from natural resources invested or consumed? What kinds of investments are made?

The export of natural resources involves the liquidation of some amount of the natural resource base. From the perspective of genuine savings an important question is therefore:

- Do policies to promote natural resource exports also embody plans for the investment of the resource royalties?

Soil erosion is a problem to be remedied at particular locales in particular countries. Where erosion is occurring at inefficient rates, one policy response would be to subsidize the adoption of better cropping and soil management practices.

In many developing countries rapid urbanization and industrialization are leading to major increases in pollution emissions and declining ambient environmental quality - this is particularly so in the metropolitan areas of Asia and Latin America. The response to this problem is not, of course, to aim for the elimination of pollution, but rather to aim for what economists would consider to be the efficient level of emissions. The policy questions this poses are:

- Do policies with respect to pollution emissions target efficient levels, where social benefits and abatement costs are equated at the margin?
- Even if the efficient level is achieved, are sufficient savings being made to offset any cumulative effects of pollution that this may entail? Since the efficient level of emissions is non-zero, there is a corresponding requirement for increases in saving in order to maintain the level of welfare over time.

¹¹ See Weitzman (1976). Recently, Sachs and Warner (1996) have shown that resource-dependent countries have had lower rates of GNP growth since 1970 than their peers. The conclusion from Gelb (1988) is that only extremely disciplined macro policies, including the means of recycling resource export revenues, can maximize the benefits and minimize the costs of resource booms.

This is a sampling of the range of policy issues raised by the analysis of genuine savings. The analysis demonstrates that there are indeed issues for each of the economic, resource and environment ministries if government commitments to sustainable development are to be met. There are also potentially strong interactions between these ministries, particularly with regard to the recycling of resource royalties into other investments, but also with respect to the macroeconomic scale of pollution damages as well.

Further intuition into genuine saving can be gained by considering how development is financed. Total investment may be viewed as being financed out of foreign borrowing, a depreciation allowance, a depletion allowance, and an environmental degradation allowance. Governments that wished to be provident would ensure that funds were set aside in the form of these allowances. Where such allowances have been made, the resulting positive rates of genuine saving measure the extent to which net wealth is being created for the future.

There are some important caveats that need to be added to this discussion of genuine saving. First, not all saving is the same, in the sense that savings sitting in foreign bank accounts belonging to a small segment within a society are unlikely to lead to development. In other words, distributional issues are not addressed in the aggregate genuine savings measure for a nation. Second, not all investment is the same, in the sense that there are both productive and wasteful investments. A key concern that follows from the analysis of genuine savings, therefore, is the *quality of investment*. Investments in human capital, especially in primary education in developing countries, are likely to be important in this regard.

The latter point raises two issues. First, the measurement of genuine saving should be

extended to include current expenditures on education as a form of government investment. Second, the analysis of genuine saving can lead to a natural expansion of traditional measures of national wealth - Box 1 examines the issues raised by considering national wealth to be the sum of human resources, natural resources and produced assets.

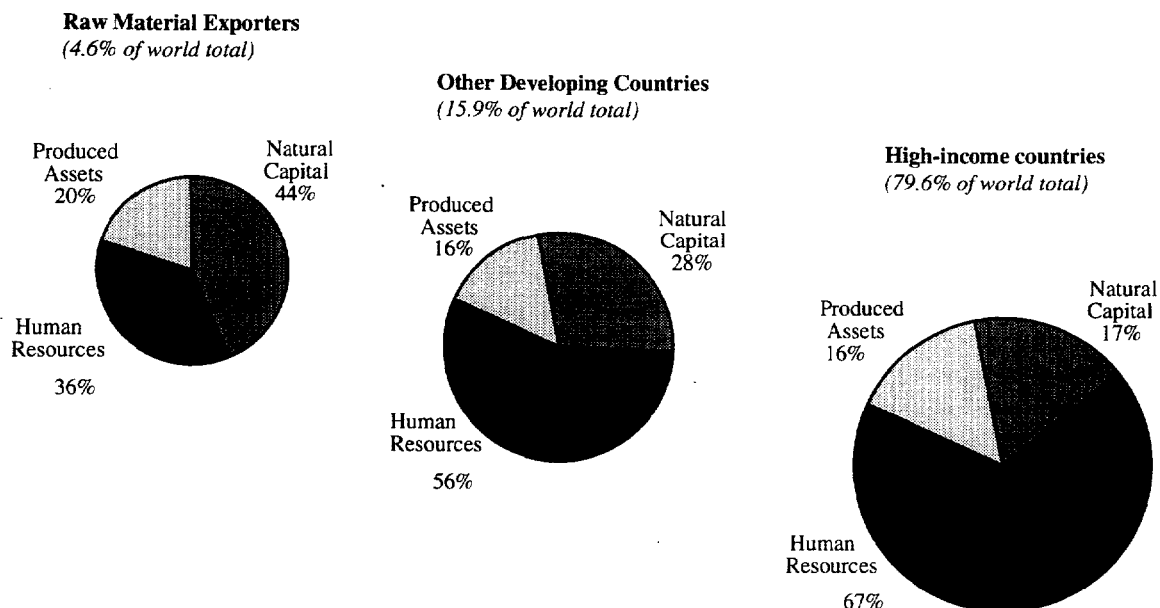
What targets should policy-makers set for genuine saving? Certainly the evidence is that high rates of saving and high rates of investment in both produced assets and human resources lead to strong growth. The analysis of genuine saving provides some important new perspectives on the growth story. First, a clearer picture of the *net* creation of wealth emerges, because the depletion of resources is treated symmetrically with the depreciation of produced assets. Countries that are liquidating natural resources rapidly and consuming the proceeds will show up clearly in this analysis (the World Bank's *Monitoring Environmental Progress*, for instance, shows many countries with negative genuine saving rates). Secondly, a new view of the growth-environment tradeoff emerges, because the damages from pollution emissions are deducted from genuine savings. Countries that opt to grow now and worry about the environment later will therefore be highlighted by the savings analysis, because the effect of this policy will be to depress genuine savings - some of the accumulation of capital is offset by the cumulative effects of pollution. If these countries maintain persistently negative rates of genuine saving, the welfare of their populations will decline.

National Accounting Aggregates (2): Other Measures

Greener measures of national income, what the SEEA terms Eco-Domestic Product (EDP), will also have an influence on policy. Such measures may indirectly encourage policies

Box 1**The Wealth of Nations**

'Back of the envelope' calculations of the wealth of nations were presented in *Monitoring Environmental Progress* (World Bank 1995). By taking the present value of the stream of income generated over the expected lifetime of the current population, a crude total wealth measure for each country was derived. Separate estimates were made of the value of natural resources and produced assets, permitting the calculation of a value of human capital as a residual. While the resulting figures for individual countries do not bear close scrutiny, broad trends across regions and income categories can be seen, as shown in the figure below.

Figure 2. Shares of National Wealth

The basic message from this analysis is that development can be conceived as a process of portfolio management: countries have a given natural endowment that may be transformed into other forms of wealth; natural resource exporters aiming to develop their economies need to balance human resources and produced assets in this process of transformation. What is remarkable about Figure 2 is that produced assets make up a near-constant proportion of total wealth across different country groupings. If there is a lack in developing countries it is in human resources.

and a mindset for politicians, statisticians, planners and others that encourages sounder

economic management. However, environmental accounting will not by itself

result in improved environmental policies; the latter can be expected to be encouraged only indirectly. Better income accounting should be seen as one element along with other tools in a multi-pronged strategy which includes environmental impact assessments at the project level, integrated environmental and economic analyses for policy work at the sectoral and macro-economic level, and public investment/expenditure reviews.

More accurate performance measurement. The primary benefit of environmental accounting is to obtain a more accurate overall picture of a nation's income and wealth as far as produced and natural capital is concerned. But even more important than adjusted 'numbers' may be the actual process of gathering the data and analyzing it, and discussing the sectoral results. There have been examples where the initial effort on physical forestry accounts has led to a national debate even though no EDP has been calculated.

Environmental accounting, by working toward valuing depletion and degradation, can help *prioritize the relative importance of environmental issues*. Environmental accounting efforts, as part of or in parallel with environmental action plans (which have tended to be more descriptive in nature) should be valuable in setting priorities. It should be mentioned in this context that there have been data gathering efforts in the past, related to or unrelated to natural resources, where bodies of data were generated, but not profitably utilized in subsequent analyses. To avoid such situations, it is important to bring a *cost-benefit perspective to data gathering efforts*, comparing the costs of obtaining additional data to the potential uses and benefits.

Indirect 'Policy Benefits.' As far as policy implications of improved accounting for the environment are concerned, these are more indirect than direct. Better numbers, it would

seem, should encourage politicians to focus on EDP rather than GDP, and should heighten environmental awareness among staff in central banks, economic ministries, and elsewhere.

Because national income accounts underlie most macro policy work, there should also be an indirect influence and benefit there. Macro economists have tended to ignore the environment, in part because it was largely outside the national accounts system; thus it was discounted as relevant only for people with an environmental interest. Integrated environmental and economic accounting, by monetizing natural resource and environmental effects, extends the range of data available to macro economists and can alert them to the relative economic importance of key natural resource and environmental areas. However, the policy implications are again more indirect than direct, and more general rather than specific. *Measuring EDP will create a 'more enabling environment,' but it may not, by itself, result in better environmental and macroeconomic policies.*

Much of what the improved accounts will indicate may also not be completely new; rather, it may provide additional information on known problems. For example, for a mineral exporting country with limited reserves remaining, improved environmental and economic accounting will show an EDP that is significantly lower than the GDP. Policy makers, whose revenues may depend on the mineral exploitation, will be aware of the fact of limited reserves and of the need to make investments in other assets, with or without improved accounting. The latter would help alert policy makers to the general need to consume less in the present and to invest more in order to sustain economic development; however, it will not force their hand or be specific in the actions that need to be taken or indicate what the 'proper' level of investment needs to be. Nevertheless, other things being equal, it should indirectly

encourage policies that lead to more sustained development.

The policy impact for mineral exporters will also depend on the risk preferences of policy makers. Reducing current consumption and increasing investments is risky for governments at any stage of development. By not reducing current consumption and increasing investment, the problem is postponed until the reserves, in the example above, are actually depleted. This postponement may be extended if new finds or technological breakthroughs are made. Again, *integrated environmental and economic accounting, with all its difficulties, can help display alternatives* to policy makers, but given the realities described above, including varying risk preferences, it will not determine the choices.

When it comes to environmental degradation, green national accounts may or may not alert policy makers to specific problems. When specific problems are identified as significant, the national accounts information itself does not indicate the type of policy action or project, if any, that should be undertaken to address the problem. Rather, the problems identified as important in the accounts need to be analyzed more in depth locally or regionally to determine the possible response. Again, in most instances, those problems may already have been known; the accounting, however, may contribute to prioritizing their economic importance.

Natural Resource Accounts

Natural resource accounts generally have a balance sheet flavor, with their emphasis on opening and closing stocks, in quantity and values, of natural resources including both commercial natural resources and non-commercial or environmental resources. As such, resource accounts form the basis of the expanded national balance sheet accounts in

the revised SNA. The principal policy and analytical uses of these accounts include:

- *Measuring physical scarcity.* As noted previously, the origins of natural resource accounts lie in the 1970's when the physical scarcity of crude petroleum seemed to present a threat to economic development. Resource accounts permit the calculation of crude scarcity indicators such as the reserves to production ratio, which gives the remaining years of resource supply at current extraction rates. However, it must be recognized that physical scarcity and economic scarcity are not the same thing, and that it is the latter that represents the constraint on development. Measures of physical scarcity can be important for critical materials, and may be an important input into such policy questions as determining the need to maintain strategic reserves of particular materials.
- *Resource management.* Again, one of the concerns when resource accounts were first established in the 1970's was that there was excessive exploitation of natural resources. What constitutes 'excessive exploitation', however, is a question lying outside the accounts, requiring dynamic economic analysis. But there are physical constraints as well, such as the fact that excessive pumping of crude petroleum from a given deposit will decrease the total amount ultimately available, as the oil reserves lose contiguity. Given a criterion for excessive exploitation, resource accounts can provide the empirical evidence for it. A variety of policy remedies can then be explored, including tenure arrangements and royalty schemes.
- *Balance sheet of the resource sectors.* The existing national accounts are substantially incomplete with regard to the resource sectors because the values of

natural resource assets are not measured. This affects the analysis of economic performance for these sectors, which in turn affects government policies with regard to the natural resource sectors.

- *Productivity measurement.* Because the balance sheet of the resource sectors does not measure the value of resource assets in the standard national accounts, the measure of productivity in these sectors is distorted, which then distorts national measures of productivity. Productivity comparisons between resource-rich and resource-poor countries are also affected by this gap.
- *Portfolio analysis and management.* Measuring natural resources in the national balance sheet implies that governments can work with a measure of total wealth in examining policies for sustainable development - see Box 1. The balance of natural versus produced assets in this measure of total wealth then becomes an important indicator as governments consider development options. This approach is even more powerful if human capital is estimated and brought into the balance sheet.
- *Valuing depletion.* A value for resource depletion is a simple byproduct of the stock-flow accounting that makes up a natural resource account. Current measures such as net domestic product do not value the depletion of natural resources. The liquidation of important components of national wealth therefore does not have any effect on standard measures of economic performance. The policy implications of accounting for depletion were discussed in the preceding sections.
- *Effects of environmental degradation.* By building living natural resources such as forests and fisheries into a resource

account, and ultimately into the national balance sheet, one of the economic effects of deteriorating environmental quality can be measured as damage to these resources. This can be an important input into policy decisions concerning the optimal level of pollution abatement for pollutants such as SO₂ or emissions of toxics into water.

Natural resource accounts, and their counterparts in the national balance sheet accounts, can therefore have wide use with regard to resource management policies and broader environmental policies.

Resource and Pollutant Flow Accounts

Resource and pollutant flow accounts are generally conceived as physical extensions to the (monetary) Input-Output (I/O) accounts. For each production and final demand sector in the I/O tables these accounts associate a physical flow of natural resources, typically as inputs such as energy to production processes, and a physical flow of wastes and emissions in the form of SO₂, NO_x, BOD, etc. With links to the I/O tables these accounts lend themselves naturally to policy modeling. Examples of policy uses include:

- *Measuring the incidence of environmental regulations and taxes.* Models based on flow accounts can be used to estimate the impact (on output and profits, for example) of existing and prospective regulations and taxes with regard to the environment. Measuring the burden of policies is an important element of policy design.
- *Estimating emission tax rates.* Where market-based instruments are being considered as a policy option, computable general equilibrium models using pollutant flow accounts can be used to estimate the approximate size of a tax - an example would be a CO₂ emissions tax, to

- achieve the policy goal of limiting emissions to 1990 levels by the year 2000.
- *Efficiency of resource use.* One important determinant of the burden that production activities place on the environment concerns the efficiency of use of natural resources. Resource flow accounts can be used directly to measure these efficiencies in different sectors, or overall per unit of GDP, and models can be constructed to examine the effects of different policies on efficiency of use. 'Energy analysis' as widely carried out in the 1970's was one example of such policy use.
 - *International trade.* Both resource use and pollution emissions can be linked to the level and structure of international trade through I/O based models. This provides the link between trade policies and the pollution burden associated with a particular structure of trade; for instance, countries that export raw and semi-finished materials will typically incur a large burden of air emissions associated with energy use. This approach can be used for both current analysis and prospective modeling.
 - *Structural change.* As in the case of linkages to international trade, resource and pollutant flow accounts in combination with I/O models can be used to explore the ramifications of structural change in the economy. This provides a link between industrial development policies and their likely effects on the environment.
 - *Macro models.* Tying resource and pollutant flow accounts to the standard macro models that governments use for economic projections would permit the reporting of environmental effects (in terms of resource throughput and pollution emissions) as a standard

component of the output from such models. Consideration of environmental effects could then become as routine as consideration of balance of payments effects when policy analysts produce projections.

- *Dispersion and impact models.* Whichever modeling approach described above is employed, the calculation of pollution emissions is the required input for 'downstream' models of dispersion and impact. Once impacts on health, living resources, produced assets and natural ecosystems have been estimated, valuation of these impacts becomes possible. This implies that the *net* benefits of policies with regard to trade and development, for instance, can be estimated, which may lead to adjustments of these policies in order to maximize benefits.

Of the *physical* accounts under consideration, resource and pollutant flow accounts clearly have links to the widest variety of policy issues.

Environmental Expenditure Accounts

Environmental expenditure accounts generally consist of detailed data on capital and operating expenditures by economic sectors for the protection and enhancement of the environment. The accounts may or may not include detail on the type of pollutant controlled or the environmental medium being protected. The prospective uses of these accounts are fairly straightforward:

- *Measurement of the total economic burden of environmental protection.* By measuring explicitly what is only implicit in the standard national accounts, environmental expenditure accounts permit macro-level consideration of whether the costs of environmental

protection are commensurate with the benefits.

- *Measurement of sectoral costs.* Environmental expenditure accounts also permit policy-makers to gauge the sectoral distribution of the costs associated with environmental regulations and taxes, an important consideration with regard to equity.
- *Measurement of unit abatement costs.* If the survey vehicles used to collect data on environmental expenditures also collect data on the amount of abatement achieved, it is possible to estimate average

unit abatement costs. These costs then become a basic input to the estimation of abatement cost curves, widely used in policy modeling, and the valuation of environmental degradation from emissions.

It should be noted, however, that measuring environmental expenditures is a subject fraught with definitional and measurement problems. To give just one example, manufacturers now often introduce new production technologies that jointly increase productivity and decrease emissions - in such a case there is no meaningful way to establish what is the cost of protecting the environment.

4 Experience with Resource and Environmental Accounting

Having set the stage with regard to the policy uses of natural resource and environmental accounting, the next task is to assess some of the empirical efforts that have been published. By now most OECD countries have official green accounting efforts underway, with statistical offices publishing or aiming to publish a variety of resource and environmental accounts. In the developing world many of the studies to date have been carried out by researchers rather than statistical offices.

The following is a brief analysis of published attempts at constructing natural resource accounts, satellite accounts, and/or altered national accounting aggregates. With the publication of the SEEA in late 1993 the groundwork was laid for a series of case studies of the application of the new satellite accounting framework, including efforts in Colombia, Ghana, Indonesia, Korea and the Philippines (the reports for these exercises are expected to be published in 1997). This section reviews the empirical experience in different countries prior to the publication of the SEEA, including the key tests of the accounting framework in Mexico and Papua New Guinea. Some of the more recent experience in OECD countries is also presented.

The assessments below are organized by country, with countries appearing in alphabetical order.

Australia

Young, M.D. (1992) Natural Resource Accounting: Some Australian Experiences and Observations, Working Paper 92/1, CSIRO, Canberra. (also published in Lutz 1993)

Natural resource accounting has been identified as one of 15 possible policy changes to promote (ecologically) sustainable development in Australia. The development of these accounts is in the early stages. In fact, Young claims that there is a fair amount of skepticism towards modified national accounts as an aid to environmental decision-making.

Young attempts to calculate a 'green' GDP by taking account of the use of renewable and nonrenewable resources use in production. Given data collection problems, many of the entries are based on 'guesstimates' which were designed to be 'environmentally generous'. The valuation method used is Repetto et al. (1989) although the document presents adjustments as modified GDP.¹² The agricultural sector accounted for almost 5% of

¹² The value of human-made capital depreciation is not deducted.

Australian GDP in 1987-88.¹³ Estimates of habitat decline and land degradation (erosion and salinity) were in the region of 0.6% to 1.6% of GDP during the period 1980 to 1989 (average 0.8%). The adjustment to GDP is therefore small.

The extraction of nonrenewable resources is a larger component of economic activity in Australia. Repetto's treatment of discoveries is used, allowing adjusted GDP to be greater than conventional GDP in any year. This is indeed found to be the case in all but two of the years during the period covered (1980-1989). Young says that this would provide very poor signals for environmental and resource management. This need not lead to a rejection of resource accounting, but to more a recognition that there are methodological issues to be resolved such as the treatment of discoveries. In addition, Young appears to include price changes in the adjustment, whereas these are usually presented in reconciliation accounts or balance sheets as a capital gain/loss. Young also makes several suggestions to improve the usefulness of adjusted accounts.

- (a) Given a population growth rate of 2% in Australia, GDP per capita should be stressed. (Of course this tells us nothing concerning how this GDP is actually distributed.)
- (b) National accounts deal mainly with marketed activities. As such they are an indicator of the level of economic activity and not a measure of welfare. Social costs and benefits should not be neglected where the non-marketed value of services from the environment might be expected to be significant.
- (c) Concentrate on regional or sectoral accounts. Geographical Information Systems (GIS) could provide data for maps

of the annual costs and benefits of land use within a region. Interestingly, whilst local land administrators and resource managers support aggregated accounting systems, they opposed a GIS-based system which would indicate the impacts of particular projects. Young envisages that this system would be able to answer an array of questions such as the likely effects of conservation programmes on land use.

McCarthy, P., 1994, Prospects for Environmental Satellite Accounts linked to the Australian National Accounts, meeting on National Accounts and the Environment, London, March 16-18, 1994.

The Australian Bureau of Statistics is producing an expanded national balance sheet account that will include land values, subsoil assets, livestock and forests as tangible assets, according to McCarthy (1994). This work is aimed at "extended economic-environmental analysis" and the development of models. An important use of the account and related analysis will be in the evaluation of the sustainability of economic activity in Australia.

McCarthy notes that there has been pressure from environmentalists and some parts of the government and the environmental protection industry to publish a 'green GDP'. This pressure has been resisted partly because of uncertainties in valuation procedures and partly because of concerns about whether green GDP would send correct signals to policy-makers. Young (1993) has been influential in urging caution in this regard.

Canada

Anielski, M. (1992) Resource Accounting: Indicators of the Sustainability of Alberta's Forest Resources, Paper presented to the International Society of Ecological Economics Conference 1992, Stockholm.

¹³ This includes farming, forestry, fishing and hunting.

Anielski presents pilot physical and monetary accounts for forest resources in Alberta, covering the period 1964-1990. The intention is to gain information on the sustainability of the services that natural capital (i.e. here, the stock of Alberta's forests) provides.

The construction of physical accounts involves the calculation an opening stock (area x volume per unit area). The relevant flows are mean annual increment (MAI), harvest, natural loss and afforestation. The trend of the net closing balance is shown to have been increasing steadily over the period, where the closing stock in 1990 was 8% greater than in 1964. (Old growth area has declined because of 'disturbances' - i.e. fire, insects and land-use change). These figures are dependent on the accuracy of data on MAI which can be checked by periodic inventories. Anielski states that sufficient information exists to construct comprehensive timber accounts for Alberta.

These accounts can be further linked to the conventional SNA through valuation of physical volumes and flows. The price of timber is subject to large fluctuations and this is reflected in the values obtained for the stocks and flows measured. The value of closing stocks therefore fluctuated year to year, although in each year (apart from 1980 and 1981) the value of harvest was exceeded by the value of growth. In this sense, Alberta's forest resources have been managed sustainably, although the value of this growth is not a component of currently measured domestic income accounts in Alberta. Values for non-marketed services are also considered, although no calculations are undertaken in this study. Extensions to measure the value of services such as amenity, carbon fixing and the provision of wildlife habitat would be interesting and go some way toward actual measurement of total economic value.

Born, A. (1992) Development of Natural Resource Accounts: Physical and Monetary Accounts for Crude Oil and Natural Gas Reserves in Alberta, Statistics Canada.

This study is part of a project to develop National Balance Sheets Accounts for Canada that include natural resources as assets. Born presents measures of Alberta's oil and gas established reserves in terms of both volume (physical) and value (monetary) during the period 1951 to 1990.¹⁴ The theoretical background to the adjustments receives detailed attention with thorough discussions of the methodological issues involved, including the 'meaning' of economic rent and the validity of the various assumptions underlying it's measurement (i.e. homogenous resource stocks, perfect competition etc.).¹⁵

The central aim of the paper is to present additions to the standard wealth accounts to include the value of gas and oil resources in the ground. Reconciliation tables present wealth accounts for Alberta's natural gas and oil resources showing opening and closing stocks. The closing stock balances of net tangible assets is equivalent to the opening stock plus the exploration costs plus volume changes plus price changes (all valued at market price, except for exploration costs and depletion). Exploration, development and operating costs all need to be deducted to obtain the rental value from which the

¹⁴ Alberta is the largest producer of oil and natural gas in Canada (i.e. in 1989 the value of it's production was 84% of the national total). It also has the largest reserves. Established reserves are recoverable under current technological and present and anticipated economic conditions. The SEEA convention of estimating proven reserves as the latter is considered too conservative for macroeconomic planning purposes.

¹⁵ Rent is often estimated as the residual of the international price after all other factor costs incurred in extraction have been subtracted.

discounted values of opening and closing stocks can be derived. This includes a normal return to capital (imputed to avoid double-counting in the wealth accounts), which Born interprets as the replacement cost value of the net capital stock, depreciation and the average yield on long-term corporate bonds. Depletion is then valued at some imputed ecological value and adjusted to a current (undiscounted) market value. The proportion of this rent in the wellhead price varied from about 37% to 74%.

The values of oil and natural gas derived reflect both the fluctuating prices for resources and diminishing stocks. The values of reserves are not apportioned to various institutional sectors of the balance sheet. These distributional aspects will be the subject of further work.

Smith, P., 1994, The Canadian National Accounts Environmental Component: A Status Report, meeting on National Accounts and the Environment, London, March 16-18, 1994.

Smith reports on the work of Statistics Canada to develop natural resource accounts in quantity and value, physical resource use and pollution emissions accounts, and environmental protection expenditure accounts. With the exception of the natural resource accounts, which will be embedded in the national balance sheet account of the SNA, these are viewed as adjuncts to the standard national accounts, and there are no plans to produce a green GDP.

Most of the policy uses of the accounts to date reflect the components that were available first, those concerning greenhouse gases. The greenhouse gas emission accounts constitute an inventory that is being used to track progress towards Canada's commitment to stabilize greenhouse emissions at their 1990 level by the year 2000. They have also been used in an Input-Output (I/O) modeling exercise examining policy options for

reaching this goal. The energy use flow accounts underlying the greenhouse gas accounts have been used by the Department of Finance in a computable general equilibrium model to examine the level of carbon tax required to achieve stabilization.

Hamilton *et al.* (1994) report on two prospective uses of the new environmental accounts. The expanded wealth accounts could be an important component of the annual report to Parliament on sustainable development required by the Green Plan (Canada's environmental policy framework). And the forest accounts being prepared in conjunction with the province of Ontario may be employed by that province in assessing the value of non-extractive uses of the forest.

Costa Rica

Solorzano, R., de Camino, R., Woodward, R., Tosi, J., Watson, V., Vásquez, A., Villalobos, C., Jiménez, J., Repetto, R. and Cruz, W. (1991) Accounts Overdue: Natural Resource Depreciation in Costa Rica, World Resources Institute, Washington DC.

The World Resource Institute undertook a natural resource accounting exercise for Costa Rica with local counterparts (Solórzano *et al.* 1991). The accounting framework basically follows WRI's previous work for Indonesia (Repetto *et al.* 1989).

The forestry account presents the loss of immediate and future timber in physical and monetary values, using stumpage values estimated separately for hard, soft and medium density timber according to distance from processing sawmills. The soil erosion account covers the loss of principal nutrients for plant growth, based on the volume of soil erosion and the cost of its equivalent in fertilizer terms. For fisheries, only the loss of the principal species in one important fishing area (Nicoya Bay) are considered, using a bioeconomic model estimated econometrically

Table 1
GDP, Resource Depletion And 'NDP'*
Costa Rica - 1970/1989
Constant 1984 Colones, millions

Year	Forestry		Agriculture		Fisheries		Total	
	GDP	'NDP'	GDP	'NDP'	GDP	'NDP'	GDP	'NDP'
1970			21044	19104			93446	82513
1971			19277	17403	139	132	94382	81858
1972			20278	18292	138	131	100912	89173
1973			23570	21488	163	158	116525	103366
1974			23835	20655	197	203	122740	108144
1975			25503	22518	196	212	125393	111155
1976			26960	24429	244	277	132310	118940
1977			31513	28960	219	284	143990	130285
1978	2829	- 1123	31258	28908	567	679	153124	138900
1979	3059	- 2861	29713	26792	763	856	160598	143277
1980	3024	- 2258	28668	25580	641	779	161894	145132
1981	3029	357	36804	33973	652	646	158237	145216
1982	2189	251	35220	32100	751	652	145932	134928
1983	2527	- 4143	33679	30794	586	503	154481	139815
1984	3071	- 4446	34540	31512	865	699	163011	147438
1985	2917	- 4776	31879	28614	1268	995	169299	153374
1986	2968	- 8703	37057	34560	1225	839	177327	158365
1987	2746	- 4920	33615	31320	1466	663	186019	170846
1988			37309	34687			207816	181352
1989			39459	36883			231289	205362

Source: Solórzano *et al.* (1991)

* Excludes conventional capital consumption allowance.

to calculate the change in sustainable harvest levels and resource rents with increasing fish effort. All expected future damages are capitalized into present values and added to the depreciation figures.

The main results are summarized in Table 1. Forest resource depreciation was deducted from gross forestry product, soil depreciation deducted from agricultural value added and fishery depreciation from gross fishery product, generating respective net product series. The net forestry product series is negative for almost all years, a result which lacks a theoretical explanation.

Finland

Kolttola, L., 1994, *The Forest Sector and the Environment, (Statistics Finland), meeting on National Accounts and the Environment, London, March 16-18, 1994.*

A pilot project on natural resource accounting began in the statistical office in 1985, according to Kolttola (1994). Complete wood material accounts in physical quantities were published in 1992. These accounts have been used in economic modeling, carbon balance accounting and in experimental monetary valuation of forest resources.

The wood material accounts are the basic element of the forest sector component of the Finnish Long Term Modeling System (FMS), employed by the government to explore development issues over the longer run. This is a simulation model which also includes energy use and air emission components.

Kolttola notes that the "relevance of information is a key question in the development of physical accounts... Efficient use of physical accounts requires close interaction between statisticians, analysts and policy-makers."

France

Grobecker, C., and Weber, J-L, 1993, La place de la comptabilité du patrimoine naturel dans les travaux de l'institut français de l'environnement, Cinquième colloque de comptabilité nationale de l'Association de Comptabilité Nationale, Paris, 13-15 décembre 1993.

Weber, J-L, 1993, Environment Statistics and Natural Resource (Patrimony) Accounting, UNDP/UNSTAT Workshop on Natural Resource and Environmental Accounting, Beijing, Apr. 20-22 1993.

The French system of 'patrimony accounts' consists of three components: element accounts, ecosystem accounts, and agent accounts. With the exception of environmental protection expenditures, these are measured in physical quantities. Grobecker and Weber (1993) describe the position of the patrimony accounts within the new French Institute for the Environment (IFEN). Resource accounts for water and forestry are the most complete to date. Potential users of the patrimony accounts were asked for their judgments concerning the application of the accounts. The natural resource accounts and resource use accounts within the overall system were judged by users to be useful for medium-to-long term management of natural resources. However,

the issue of the cost of fully implementing the accounts was raised.

What is distinctive about the French system is the notion of patrimony. As Grobecker and Weber note, "it is... what we have inherited from our ancestors and what we should bequeath (*léguer*) to future generations." Patrimony accounts are viewed as a tool for the management of this process.

Weber (1993) states that the patrimony accounts can also be the basis of a system of environmental indicators. The inadequacy of existing environmental indicators is considered to be one cause of environmental degradation. One example of the use of the forest accounts component in resource management is described: the accounts for annual growth versus cut for forest resources in the Gascogne were used as the basis of projections to settle a local dispute concerning whether forest resources were being exploited sustainably.

Germany

Radermacher, W., and Stahmer, C., 1994, Environmental Accounting and National Accounts in Germany, (Statistisches Bundesamt), meeting on National Accounts and the Environment, London, March 16-18, 1994.

As Radermacher and Stahmer (1994) report, the Federal Statistical Office is engaged in the development of a system of Environmental Economic Accounting (EEA). This will have five subject areas: (i) material, energy and emission flow accounts, tied to the I/O accounts; (ii) a geographic information system (GIS) on the use of land and space; (iii) a set of indicators of the state of the environment; (iv) environmental protection activities accounts; and (v) accounts of the imputed costs of achieving standards for sustainable use of the environment (this has a strong affinity with the work of the Netherlands, described below).

One of the more innovative aspects of the EEA is the proposal to link GIS, indicators and accounting systems - progress along these lines will be worth monitoring. An important prospective use of the material, energy and emission flow accounts is in the analysis of international trade, to look at material use and pollution emissions implicit in the pattern of trade.

With regards to the main policy uses of the EEA, Radermacher and Stahmer are explicit: "the EEA is to provide data for economic decisions; not for technical checks and regulations, not for the implementation of administrative measures by environmental or planning agencies, but as instruments for assessing external effects and for developing efficient economic countermeasures."

Hamilton *et al.* (1994) report on discussions with the Federal Environment Ministry concerning other potential applications of the EEA. The list includes: waste issues, including recycling regulations and the possibility of a waste tax; information to support policies to curb CO₂ emissions; measurement of which sectors bear the heaviest burden of environmental protection costs; and the analysis of transboundary pollution issues.

India

Parikh, K., J.Parikh., V.K.Sharma and J.Painuly (1992) *Natural Resource Accounting: a Framework for India*, Indira Gandhi Institute of Development Research, Bombay.

The Indira Gandhi Institute of Development Research in Bombay (Parikh *et al.* 1992) has prepared an exploratory report on natural resource accounting for the Indian Ministry of Environment and Forests. A framework is established which suggests assessing the physical environmental impacts of selected production and consumption activities, including the informal sector, and physical accounts for soil, air, water, forests,

biodiversity and various non-renewable resources. After that, economic valuation would be investigated with the aim of ultimately constructing integrated economic and environmental accounting (IEEA), as called for in Chapter 8 of Agenda 21.

The purposes of the exercises are listed as:

- (a) to keep track of the resource base and the state of the natural environment a general *monitoring* function; and
- (b) to remind people of the environmental consequences of economic activities and hence to 'alter our perception of what kind of development is desirable and, in turn, the policy choices we make' (Parikh *et al.* 1992 p.2)- a *persuasive* function.

Outline schema are presented for natural resource accounts, but little physical data and no economic data for India as a whole are reported.

Indonesia

Repetto, R., Magrath, W., Wells, M., Beer, C., and Rossini F. (1989) *Wasting Assets: Natural Resources in the National Accounts*. Washington: World Resources Institute.

One of the best-known natural resource accounting studies is the pioneering exercise by the World Resources Institute (Repetto *et al.* 1989) for Indonesia. Changes in the stocks of natural resources (oil, forests and soil) are considered in the capital and flow accounts.

The valuation principle assumed for oil and forests (timber) is the net price method: rents are determined by the international resource commodity price less all factor costs incurred in extraction. This implies that domestic and international markets for the resource are assumed to be perfect, and optimal paths of extraction follow the Hotelling Rule. Opening and closing stocks in each period are multiplied by the respective rent, and the

Table 2
GDP, Resource Depletion And "NDP"
Indonesia - 1971 to 1984
Constant 1973 Rupiah, billions

Year	GDP	Resource Depletion	"NDP"
1971	5545	+ 1126	6671
1972	6060	- 100	5967
1973	6753	- 279	6474
1974	7296	+ 2605	9901
1975	7631	- 1121	6510
1976	8156	- 684	7472
1977	8882	- 1711	7171
1978	9567	- 1607	7960
1979	10165	- 2219	7946
1980	11169	- 2663	8506
1981	12055	- 2215	9840
1982	12325	- 1764	10561
1983	12842	- 2870	9972
1984	13520	- 2330	1118

Source: Repetto et al. (1989)

variation between each represents the (dis)investment in natural capital.

For soil erosion, the loss of potential future farm income is considered equivalent to the depreciation of an economic asset. Incremental erosion due to human intervention is estimated in physical terms by the difference between per-hectare loss on forest land and on dryland farming (tegal). Yield-erosion relationships are also estimated, with the farm income declining linearly as erosion increases. The one-year costs of erosion are then capitalized to obtain the total present value of the future stream of productivity losses associated with the erosion in that year, which is considered to be the economic measure of soil depreciation.

The results from the three resource accounts are aggregated into one measure of 'natural capital domestic investment' ('NDI'), which is added to the GDP (Table 2). The new aggregate is named 'NDP', but it is still an incomplete measure of net domestic product

because it ignores the depreciation of produced assets. The figures are usually below the conventional measures, however in 1971 and 1974 the 'NDP' is higher than the conventional GDP, owing to oil discoveries¹⁶ and price changes.

Japan

Uno, K. (1989) *Economic Growth and Environmental Change in Japan: Net National Welfare and Beyond*, in Archibugi, F. and Nijkamp, P. (eds.), *Economy and Ecology: Towards Sustainable Development*. London: Kluwer Academic Publishers.

The estimation of environmental damages at a national level in Japan is linked with efforts to obtain a Net National Welfare measure (NNW) in line with the framework developed by Tobin and Nordhaus (1972). The starting

¹⁶ This treatment of discoveries as additions to net product is one of the most controversial aspects of the study. See Hartwick (1993), Hamilton (1994).

point is the conventional concept of GDP and then welfare adjustments are made.

The first NNW estimation was carried out by the Economic Council of the Government of Japan in 1973, covering the period from 1955 to 1970. The results were subsequently updated, covering the period up to 1975. Finally, a third attempt at NNW estimation was made by Uno (1989), bringing the figures up to 1980 and 1985.

The main adjustments in the latest version are:

- Government consumption: only education, health, social security and welfare services are considered in the NNW estimates. Other government expenditures are excluded because they are considered defensive expenditures or to maintain consistency with earlier calculations.
- Personal consumption: defensive expenses and purchases of consumer durable goods are excluded, the latter being replaced by an imputation of their services.
- Capital investment: investment in plant and equipment, social overhead, and housing are excluded and replaced by imputations of their services.
- Leisure time: the value of leisure time is imputed based on average wages per hour, adjusted by age, group and sex.
- Non-market activities: the value of domestic services of housewives is imputed based on the average wage of female workers.
- Environmental damages: the social costs of environmental pollution are estimated by the expenses necessary to recover a "normal physical environmental level" in terms of air pollution, water pollution and waste treatment. The direct monetary estimation of damages is considered

theoretically a better approach but it could not be undertaken because of the lack of data.

- Losses due to urbanization: although the scope of the possible negative effects may be larger, only increasing distances for commuters and traffic accidents are imputed. The former comprises the physical and mental fatigue caused by increased commuting hours, and the latter provides valuation of deaths and injuries based on the "value of life" and the average value of compensation in case of accidents.

The results (Table 3) show that the gap between NNW and GDP increased during the whole period, an interesting addition to the debate raised on whether or not economic growth in Japan contributed to improving human well-being.

Mexico

van Tongeren, J., Schweinfest, S., Lutz, E., Gomez Luna M. and Guillen, F. (1991) Integrated Environmental and Economic Accounting: A Case Study for Mexico Environment Working Paper No. 50, The World Bank, Washington DC. (also published in Lutz 1993)

The study case for Mexico (Van Tongeren et al. 1991) was carried out in 1990 and 1991 jointly by the United Nations Statistical Office (UNSO), the World Bank and the National Institute of Statistics, Geography and Informatics of Mexico (INEGI). It was the first empirical experience with the overall analytical framework developed in UNSO's Draft Handbook on Environmental Accounting (United Nations, 1990), providing two measures for the Environmentally-Adjusted net Domestic Product (EDP) for the year 1985.

The System of Economic and Environmental Accounts for Mexico (SEEA) was constructed by an expansion of the conventional structure of the National Accounts. The main

Table 3
 NNW and GNP: Japan - 1955 to 1985 in constant 1970 Yen, billions

	1955	1960	1965	1970	1975	1980	1985
GNP	17268	26183	41591	72144	93260	118105	143387
NNW	18036	23128	32116	47548	74231	90646	103781
Gov. Expenditures	1199	1374	2254	2988	3865	4283	4887
Pers. Consumption	10427	14706	22168	32097	43003	54009	61700
Gov. Capital Serv.	62	99	169	317	559	756	1103
Durable Goods	91	195	755	2342	4187	5270	6183
Services	4871	6098	7325	10509	16759	18961	20816
Leisure Time & Non-market Act.	1876	2388	4068	7213	12707	12571	13079
Environmental Damages	-38	-1037	-3735	-6805	-5729	-3932	-3103
Urbanization Losses	-452	-695	-889	-1113	-1119	-1272	-1514

Source: Uno (1989)

innovation is the enlargement of the asset boundary, including oil depletion, degradation concerns (water and air pollution, soil erosion, ground water use and the deposition of solid wastes), land use concerns (water and air pollution, soil erosion, ground water use and the deposition of solid wastes), land use concerns and deforestation. The EDP measures are obtained by deducting the cost of resource depletion from NDP (EDP1) and environmental degradation (EDP2).

Three approaches were used to value the accounts in physical units. The depletion figures were obtained by calculating the value of the stock of assets by the net price method, i.e. the market value minus cost including a normal profit. Alternatively, the

same figures are presented employing the user cost approach developed by El Serafy (1989). Finally, the avoidance cost approach was used for the valuation of quality changes in natural assets stocks.

The results are presented using an input-output scheme. Therefore, they show not only the macro effects of the depletion and degradation but they also identify the economic use of natural resources as well as the environmental protection expenses made by different sectors. Table 4 summarizes the main results. This table shows that net domestic product would be significantly affected if the changes in natural capital were considered: net accumulation would decrease from 11% of NDP to -15% if the most restrictive measure (EDP2) is adopted.

Table 4
 NDP, EDP1 And EDP2
 Mexico - 1985
 1985 Mexican Pesos, billions

	NDP	EDP1	EDP2
Net Product/Expenditure	42060516	39662772	36448314
Final Consumption	34948897	34948897	34890558
Capital Accumulation, Net		2305910	-850209
- Economic Assets	4703654	4703654	4703654
- Environmental Assets	4373654	-2397744	-5553863
Exports-Imports	2407965	2407965	2407965

Source: Van Tongeren, J. *et al.* (1992)

The Netherlands

de Haan, M., Keuning, S.J., and Bosch, P., 1993, Integrating Indicators in a National Accounting Matrix Including Environmental Accounts (NAMEA), NA 060, 1993, Voorburg: Central Bureau of Statistics.

Hueting, R., and Bosch, P., 1994, Sustainable National Income in the Netherlands: The Calculation of Environmental Losses in Money Terms, Statistics Netherlands, meeting on National Accounts and the Environment, London, March 16-18, 1994.

There are two basic streams of green accounting work at the Central Bureau of Statistics. The first, described by de Haas *et al.* (1993), is the construction of a 'national accounting matrix including environmental accounts' (NAMEA). As well as breaking out the standard national accounts in matrix form, cells in the extended matrix measure pollution emissions associated with different economic sectors. These emissions figures are then grouped into themes, e.g., greenhouse warming, for which policy goals have been established, and then weighted into 'pressure equivalents' so that the distance from the

policy goal can be measured in aggregate. This effectively combines accounting approaches with the environmental performance indicator work of the Netherlands Ministry of Environment and Physical Planning (see Adriaanse 1993). The themes include the greenhouse effect, ozone depletion, acidification, eutrophication, and waste production.

Hueting and Bosch (1994) describe a parallel approach to green accounting. They aim to measure sustainable national income by valuing environmental losses as the cost of achieving sustainable use of the environment. While policy goals are not explicitly discussed in this work, achieving sustainable use of the environment is a stated policy of the Netherlands government. Hamilton *et al.* (1994) note another aspect of this work: since sustainable use of the environment is a global rather than purely country-specific concept, the effects on sustainability of the Netherlands' imports of raw materials from other countries also needs to be considered. This raises interesting questions concerning how, for instance, unsustainable resource harvest policies in raw material supplying

countries should be treated, not just in the accounts but in trade policy as well.

New Zealand

Clough, P. (1991) Natural Resource Accounting for New Zealand's Indigenous Forests: Report to the Ministry of Environment, New Zealand Institute of Economic Research (Inc.), interim draft.

The feasibility of compiling pilot accounts for New Zealand's indigenous forests is considered in this report, which draws upon a more general application of natural resource accounts (NRA) in New Zealand (Wright, 1989, 1990). The intention in this work is to derive an NRA that shows stocks at given periods and the flows between these periods. Owing to the relatively small volumes of economically exploitable timber, much of the discussion is concerned with non-marketed values and the total economic value of the resource in question.

Forests are divided into three classes - protected, non-commercially available and commercially available. The values of these classes are in turn divided into four components - extractive timber, externality user, amenity and option (non-use) values. Valuation problems exist, although there are techniques to derive these values including stated preference (contingent valuation) and revealed preference (hedonic pricing, travel cost) methods. The possibility of double-counting arises where in some revealed preference techniques the value of amenity or recreational value has already been attributed to another sector (say, tourism). This is not a problem in microeconomic cost-benefit studies but arises in an aggregate exercise such as national accounting. Non-use values such as biodiversity present more complex measurement problems, although, for example, contingent valuation could be employed (Munasinghe, 1992). The author illustrates one measurement approach whereby forest classes are ranked according

to their diversity based on a diversity count per unit area multiplied by abundance of this species per unit of area.

Norway

Aaheim, A., and Nyborg, K., 1993, Green National Product: Good Intentions, Poor Device?, Research Department discussion paper No. 103, November 1993, Statistics Norway.

Alfsen, K.H., 1993, Natural Resource Accounting and Analysis in Norway, Conference on Medium-Term Economic Assessment, Oslo, 2-4 June, 1993.

Norway began its resource accounting work in the 1970's when concerns about physical scarcity of resources and resource management were at the forefront. The original ambitious workplan has gradually been scaled back to a core set of accounts, as the policy usefulness of these accounts has become an explicit criterion for their development and continuation. The Norwegian experience is particularly pertinent to the topic of this paper, therefore.

The first point to note is that the Norwegians are not keen on the notion of green GDP, as evidenced by Aaheim and Nyborg (1993) of the Central Bureau of Statistics. Their reasons center on whether it is possible to measure green GDP (or other green national accounting aggregates) in any meaningful way - if the answer to this question is negative, then policy should not be based on green aggregates.

There are several strands to the argument against green aggregates. First Aaheim and Nyborg point to empirical evidence concerning the divergence between 'willingness to pay' for environmental amenities (or to avoid their being damaged and diminished) and 'willingness to accept compensation' for environmental amenities that may be lost. This casts doubt on contingent valuation approaches to valuing the environment. Next, marginal abatement

costs only equal marginal damages when you are at the optimum level of pollution emissions, so that using the former to value environmental change, as many economists argue on both practical and theoretical grounds, is not justified. Third, green GDP calculations typically do not include general equilibrium effects - roughly speaking, internalizing the value of environmental damages should affect all prices in the economy, with consequences for resource allocation decisions throughout the economy. Finally, expanding the measure of national wealth to include natural resources and the environment relies on future values of extraction and resource prices that are inherently uncertain.

Alfsen (1993) reviews the Norwegian experience with natural resource accounting and analysis. Natural resource accounting sprang from a desire for better long term resource management. Several ancillary benefits of the project were foreseen: collection of new and improved data for monitoring resource use; reducing duplication in data collection; and building conformity between resource data and traditional economic statistics. Accounting approaches were deemed most useful where quantity is important, rather than quality. Accordingly, the first accounts were for energy, fish, land use, minerals, forests, and sand and gravel - inventories of air emissions were added later.

The initial policy concerns motivating the accounts in Norway were with the physical scarcity of resources and their (mis)management. The supply and demand responses to the oil shock of the 1970's that have been observed have reduced the concern about physical scarcity. Today the resource accounting work is part of an ongoing effort to integrate resource and environmental issues into existing economic planning procedures. The focus of this effort has gradually narrowed to energy resources and

air emissions, as well as the analysis of the domestic consequences of international protocols to which Norway is a signatory. The accounting structure embraces both reserve and use accounts, and the latter can be quite detailed, particularly in the case of energy. The energy and emissions accounts are now built into the Multi-Sectoral Growth Model (MSG), which is used by the Norwegian government to explore long term economic prospects.

The presentation of economic, resource and environmental variables as standard outputs of models such as MSG is key in focusing decision-makers on the linkages between these policy areas in Norway. In addition, the use of common data and models in the analysis of natural resource issues has facilitated communication between the Ministries of Finance, Environment, and Petroleum and Energy. The questions posed to the models are important ones: Are environmental targets compatible with economic goals? How will any proposed policy change affect both the economy and the environment? How will future resource availability and future states of the environment affect economic development?

Papua New Guinea

Bartelmus, P. Lutz, E. and Schweinfest, S. (1992) Integrated Environmental and Economic Accounting: A Case Study for Papua New Guinea, Environment Working Paper No. 54, Environment Department, World Bank, Washington DC. (also published in Lutz 1993)

The SEEA has been built on the premise that national accounts provide the most widely used indicators for policy-making, but that they neglect important long-term considerations. Papua New Guinea (PNG) was chosen for this case study as it is in the early stages of industrialization - some 90% of the population live in rural areas.

Physical resource accounts can be linked to the monetary balance sheets and flow accounts of the SNA. Bartelmus et al undertake this for 2 elements, namely the identification of environmental protection services and of corresponding expenditures, and the inclusion of asset balances for produced and non-produced tangible assets. Public environmental expenditure by central government is a relatively small (but increasing) part of GDP in PNG - an average of 0.27% of GDP from 1986 to 1990 (current prices). This represented an average of 0.74% of the total government budget.

Monetary balances were prepared for subsoil assets using available data on net revenues and average reserve life expectancy per mine to obtain a value for an opening stock. The closing balance for 1989 is negative, owing to the closure to the largest mine in PNG (Bougainville) and a slump in mineral prices in that year. Bartelmus et al. suggest that the use of some long-term average price could avoid this problem. The value of depletion involved in the calculation of the closing stock forms the basis of an adjusted net value added (NVA1) and its sum total, EDP1.

For measuring annual depletion using both the net price (Repetto et al 1989) and 'user cost' (El Serafy 1989) approaches were employed. With a 10% discount rate and data on the life expectancy of mines, the user costs for the years 1985 to 1990 amounted to 1.4% of GDP in 1987 and 0.3% of GDP in 1989. The fluctuations were due to discoveries and the closure of the Bougainville mine. Discoveries do not alter the adjustment as they are treated as 'other volume changes' in the SEEA monetary balance sheets.¹⁷ Price fluctuations are responsible for the large variations in net price from 1985 to 1990. The level of EDP1 is in the order of 1% to 9% lower than NDP.

¹⁷ Discoveries are considered to be natural fluctuations and not the result of economic production.

Depreciation of renewable resources can be measured using a variant of the net price method - i.e. harvest minus net growth. Bartelmus et al. do not advocate the user cost method for these resources as the lifetime of the resource is potentially very long and hence user cost, very small. Where data are reliable, the calculation of this rent can give the government information concerning the appropriate level of taxes and royalties. About 75% of the total land area of PNG is covered by forests. The forestry sector is in economic terms, relatively small (about 4% of GDP). Data on total forests are also sparse and unreliable, although some data are available in physical terms, conveying the impression that the amount of logged-over land has been increasing. Shifting cultivation has also been responsible for net deforestation over the period 1980 to 1990. A zero adjustment is proposed for fisheries rents, as it is estimated that annual catches are presently below maximum sustainable yields (although no estimates of fish stocks are available).¹⁸

Environmental quality in the SEEA is usually costed at potential restoration or avoidance costs. A supplementary approach is taken here, because of the existence of compensation schemes for local environmental effects (i.e. 'markets' for welfare effects of environmental impacts in a particular area). Low and high bound annual estimates of impacts from sectors are derived based on assumptions as to the social value of the environment (from 1980 to 1990). These sectors and respective degradation values (in terms of % of NDP) are agriculture (forest clearing for cultivation) - 0.3% to 4.4%; forestry (logging activities) - 1.2% to 1.8%; mining (localized water pollution) - 1.3% to

¹⁸ The fisheries sector contributes 0.3% to GDP. Bartelmus *et al* note that non-marketed (i.e. subsistence) output from fishing could amount to about 13% of GDP.

3.8%; and the energy sector (hydropower) - 0.1% (one estimate).

The lower bound adjustments (together with the net price adjustments from EDP1) form EDP2, which is some 3% to 10% lower than NDP in the short time period studied. Whilst actual consumption did not exceed NDP as usually defined, it is greater than EDP2 from 1986 to 1990 (apart from 1988).

The Philippines

Cruz, W. and Repetto, R. (1992) The Environmental Effects of Stabilisation and Structural Adjustment Programs: The Philippines Case, World Resources Institute, Washington DC.

In previous national accounting studies, WRI focused in detail on how to undertake adjustments to national accounts (Repetto et al. 1989; Solorzano et al. 1991). In this study, the focus is on 'uses' and specifically the Philippines' experience with stabilization and structural adjustment programmes. Conventional macroeconomic accounting frameworks do not consider the environmental consequences of such policies. In contrast, 'natural resource accounting provides a macroeconomic framework for evaluating ecological decline' (p17).

Resource depreciation is estimated for forestry, soil erosion and coastal fisheries. Combined, these estimates averaged annually about 4% of GDP (and 20% of gross domestic investment) from 1970-87 (where the majority of this loss is accounted for by timber extraction). This was greater than external debt, increasing at a rate of 3.2% of GDP as indicated by a deteriorating balance of payments position. Cruz and Repetto see this increasing liability as symptomatic of the worsening balance sheet for natural assets. However, it is the debt issue that has received the most attention. Natural resources were run down and the proceeds used to finance consumption or inefficient investments or were lost in capital flight. The

macroeconomic policy regime of import substitution and the distortion of domestic terms-of-trade in favor of industry led to negative net investment in the primary sector (i.e. agriculture) during the 1970's and early 1980's.

The 'conventional view' is that stabilization and structural adjustment policies lead to the increased exploitation of resources the export of which earns precious foreign exchange. However, Cruz and Repetto contend that in the case of the Philippines this exploitation occurred before these policy regimes were imposed and therefore rents accrued to these resources prior to the shift in policy regime. Hence, even if market conditions favored further exploitation, this historic legacy would result in supply constraints being encountered. The environmental impact of the policy shift was felt in the increased exploitation of open access resources which provide vulnerable ecosystem functions. Ultimately, overuse of marginal resources such as forest lands, mangroves and fisheries is unsustainable and activities are then transferred to other fragile areas. However, this exploitation is largely undertaken in order to provide subsistence for landless laborers and will be non-marketed. As such, national accounts will contain little or no record of these activities and hence no rent can be imputed. In order to infer the full environmental effects of stabilization and structural adjustment policies, information must be sought above and beyond green national accounts.

Stabilization policies are short-term measures to correct balance-of-payments and national budget deficits. Structural adjustment is aimed at longer term efforts to 'free up' factor markets and generally to dismantle inefficient intervention. Environmental consequences are not usually of paramount concern in these endeavors. Cruz and Repetto attempt to redress the balance using a Computable General Equilibrium (CGE) model which

includes land as a separate factor of production. Then the environmental effects of a combined policy of trade liberalization and a 20% devaluation are considered. The policy leads to increased GDP but increases soil erosion, fishing (marginally), mining, logging and energy use. The model also points to policy prescriptions such as the levying of resource rent taxes as a way of raising revenues without inflicting 'pain' on the national economy, which would have the effect of encouraging conservation of marketed resource use.

Sweden

Hultkrantz, L. (1992) "National Account of Timber and Forest Environmental Resources in Sweden", *Environmental and Resource Economics*, 2: 283-305.

Hultkrantz presents environmental accounts for the forestry sector in Sweden. His adjustments are three-fold:

- a) An imputation for the value of the net change in the growing stock of timber, referred to as direct forest values. This is a stock adjustment - i.e. the value of the change in the forest stock as measured by timber rents.
- b) The value of (sustainable) activities such as berry and mushroom picking, meat from hunting game. These are service flows from the forest.
- c) Stock adjustments for the value of the change in non-commercial environmental assets. These assets are biodiversity, carbon sinks, exchangeable cations in soil (i.e. acidification) and lichen stocks (that provide the service of reindeer forage).

Hultkrantz finds that in 1987 there was a 'depreciation' in the stock of diversity of flora and fauna living in Sweden's forest habitats. Two separate methodologies are proposed to measure this change. The first is based on a contingent valuation study concerning the protection of 300 endangered species in

Sweden (Johansson, 1989). The willingness-to-pay measure is then aggregated over the Swedish population. A total WTP of some 3.6 million SEK per year is inferred as representing the value of depreciation of biodiversity in 1987.

However, an alternative approach was based on the total area of protected land required to obtain a 'reasonable' level of protection for biodiversity. In Sweden it is estimated that this criterion would imply the preservation of habitats on 10% of total forested land as a minimum target. Currently, an estimated 5% of forested land in Sweden is protected in reserves (or for other reasons). To meet the 10% target, annual protection costs must be increased. An estimate of the timber rents foregone as a result of this additional protection results in a higher depreciation charge of 600 million SEK.

Statistics Sweden, 1993, Environmental Accounts: Progress Report on a Swedish Government Commissioned Project to Develop Physical Natural Resources and Environmental Accounts, May 1993.

Statistics Sweden has been given specific instructions by the government to produce physical resource and environmental accounts as supplements to the traditional national accounts (as reported in Statistics Sweden 1993). The initial accounts will be for energy and heavy metals (cadmium, lead, chromium and mercury), but this work will be expanded to cover other area where Parliament has passed environmental policy resolutions: CO₂, SO₂, NO_x, hydrocarbons, and discharges of chlorinated organic compounds by the pulp and paper industry.

The statistical office has also been asked to work with the National Institute of Economic Research to develop methods and models for measuring the links between the economy and the environment. The goals of this work are numerous: analysis of the contributions of

different sectors of society to national and international environmental goals; assessment of the environmental and economic effects of different control regimes; and analysis of the effects on the environment of structural change in the economy. The work is expected to lead to a tool for the formulation of long term economic and environmental policy. A possible long run development is the use of the resource and environmental accounts to produce an adjusted measure of national product.

Official resource and environmental accounting work in Sweden is at a preliminary stage.

Tanzania

Peskin, H.M. (1989b) Accounting for Natural Resource Depletion and Degradation in Developing Countries, Environment Department Working Paper No. 13, World Bank, Washington DC.

The most part of this paper is devoted to an outline of Peskin's methodology behind the concept of Net Environmental Benefit. However, the final section does provide an adjusted account that imputes a value for the depletion of forest resources in Tanzania due to fuelwood collection. The author notes that perceptions of the usefulness of indicators such as national accounts ultimately depend on the ability to measure what people perceive to be of importance and in the context of the environment this will involve efforts to adequately measure changes over time in the stock of natural capital. A decrease in the goods and services that capital can produce over time is termed physical depreciation. As the stream of income produced by this capital is reduced it is also a case of value depreciation. However, value depreciation can also occur due to changes in tastes and technology.

The adjusted accounts presented by Peskin deal with the value of physical depreciation of forests in Tanzania for the year 1980

attributable to fuelwood production. Some imputation of the gross value of this production is already made in the Tanzanian accounts. This, Peskin believes is undoubtedly an underestimate as it does not record a significant nonmarketed component (i.e. fuelwood collection for household use). There is also no imputation for depletion of natural capital. By multiplying an estimated 137 million working days per year spent collecting fuelwood by the minimum daily wage, a proxy for the value of depletion is obtained. The final imputation must be net of the value of regeneration of forest, the physical measure of which is the mean annual increment. The final figure obtained is 1906 million Tanzanian shillings which is about 5% of conventionally measured GDP in 1980 and considerably greater than the marketed imputation for fuelwood production in that year.

Thailand

Sadoff, C.W. (1992) The Effects of Thailand's Logging Ban: Overview and Preliminary Results, Thailand Development Research Institute.

In terms of GDP growth, Thailand has often been described an economic success story. These impressive growth rates have been achieved through a run-down of natural assets, although whether or not this is sustainable is open to question. Sadoff attempts to show how an adjusted national accounting framework can be used to analyze this proposition and the effects of Thailand's logging ban of 1989 in response to major flooding in 1988.

Making the appropriate adjustments for the user cost and net price approaches, Sadoff finds that the resulting average adjusted aggregates are 1.5% and 2.2% of GDP respectively over the period 1970 to 1990.¹⁹

¹⁹ Deductions are made from GDP. No account is taken of the depreciation of man-made capital.

However, throughout the 1970's (the period of peak deforestation), whilst the level of adjusted domestic product is revised downwards, the modifications suggest that growth has been understated (although not significantly). From 1980, the value of total rents (however measured) declined significantly. In the absence of any evidence with respect to prices or extraction activity, this might be attributed to increasing costs as the forest stock dwindles. Since the logging ban, measured total rents have been almost insignificant, where rates of deforestation have fallen some 88% from pre-ban levels. There remains much illegal clearing. Commercial clearing has decreased by about 55% of 1980 levels.

Sadoff claims that the logging ban has led to increased rates of logging in neighboring countries which do not practice Thai management practices. Some of these countries - notably Laos and Vietnam - have announced plans designed to stem these trends. In conclusion, it is stated that the ban has had little of the adverse economic costs claimed at the time but has also had little of the environmental benefits, as deforestation continues. The dissipation of total rents from 1980 onward is perhaps some indication that timber resources have been used inefficiently. Finally, Sadoff contends that simulations using the values obtained in the study show that a more efficient policy would be a combination of sustainable management practices where logging is permitted and a tightening of the ban elsewhere.

United Kingdom

Adger W.N. and Whitby, M. (1993) National Resource Accounting in the Land-Use Sector: Theory and Practice, European Review of Agricultural Economics, 20: 77-97.

This paper is one of the few that uses results derived from stated preference studies in a national accounting framework. Using these

techniques, the (discounted) total economic value (TEV) of environmental services can be inferred, where the TEV is the value of the services of a resource and is the sum of direct use, indirect use and existence values. Adger and Whitby state that they are not couching these adjustments in terms of sustainable income but are instead providing an indication of the relative contribution of the agriculture and forestry sector to welfare.

The use of nitrogen in agriculture has grown considerably since 1978, leading to pollution of water resources in the UK. Hanley (1989) surveyed households in the Anglian Water Authority area in order to estimate the benefits of the abatement of agricultural nitrate pollution in terms of cleaner drinking water. This was valued at £13 per household, which gives an aggregate yearly benefit of the improvement of water quality of £10.8 million. The agricultural and forestry sector provides carbon fixing services for the emissions of other sectors (Adger et al. 1991). Using Anderson's (1989) estimate of a social cost of £31 per tonne of carbon and an estimate of net carbon emissions of -4.75 million tonnes, a value for this carbon credit benefit of £146.2 million was obtained. Positive externalities are also associated with landscape, wildlife and recreational benefits on public areas. The adjustment for positive flows of services from these areas in 1988 is £888 million.

The use of stated preference techniques is not without controversy - e.g. the existence of repeated large discrepancies between willingness-to-pay and willingness-to-accept measures of welfare (Knetsch, 1989). Aggregation to the national level has its own associated problems and may contain biases depending on the degree of substitutability or complementarity between, say, designated areas providing amenity values. For example, if these areas are substitutes, then estimated aggregate WTP will be overvalued.

In sum, Adger and Whitby find that adjusted Net Product is about 25% greater than conventional Net Product for the UK agricultural sector. This is due to the positive value of carbon fixing and water quality improvement. The only deduction made is for defensive expenditures.²⁰ The authors do not estimate the change on the previous accounting period, so an assessment of net natural capital deterioration cannot be inferred. Many sources of degradation are excluded, as the authors admit (and this equally applies to other environmental services). The uses of the account are tentative but indicate that policies that degrade the countryside are likely to have larger welfare impacts than will be apparent by looking at the conventional accounts. This result only becomes apparent by emphasizing the non-marketed services that the sector provides.

Bryant, C. and Cook, P. (1992) Environmental Issues and the National Accounts, Economic Trends, No. 469.

This paper represents an application of the various strands of resource accounting approaches to the UK. Physical data are assembled in a resource account under four headings - nonrenewable sub-soil assets (economically recoverable reserves of oil and natural gas, technically extractable coal), forests, air and water (emissions and disposals of pollutants rather than environmental quality itself). The data is assembled along the lines of the SEEA in balance sheets for 1990 in both physical terms and, where possible, monetary terms.

²⁰ These included payments to maintain landscape and wildlife amenity, as well as the promotion of recreation and education. Together with an estimated £5.6 million in expenditures to clean up agricultural pollution and £9 million to meet EC standards for drinking water, these (non-household) defensive expenditures amounted to £57.6 million in 1988.

Depletion is estimated for nonrenewable resources using both the net price and user cost methods, although the relative merits of either are not considered. The net price method is divided into two measurements - (1) the value of the change in the stock during the accounting period, while (2) uses the more usual method of taking the gross margin, net of extraction costs. It is not certain whether the former makes any allowance for a return to capital. Discoveries are not treated as negative depletion in contrast to Repetto (1989). In nearly all instances, as might be expected, user cost is a lower proportion of gross revenues of the sector than net price (1) which in turn is less than net price (2). In the case of the net price (2) approach, total rents for oil and gas were in the region of 0.5% to 6% from 1980 to 1990. All three methods are subject to fluctuations owing to the volatility of prices.

There is no calculation of rent for the coal industry. This is due to the difficulties in interpreting the meaning of 'net receipts' in the mining industry. As there are no profits in the sector, Bryant and Cook state that rents must be zero. This is interpreted in another way with reference to the user cost approach. There are relatively large reserves of coal, although the problem of 'non-existent' profits arises here as well. One implication of these findings is that coal reserves should be reclassified as environmental assets - i.e. these reserves are not economically extractable.²¹ No data on reserves for sand, gravel, gypsum, ball and china clay, limestone, granite, slate and salt are available. These extractive sectors contribute little to national output and the resources involved are relatively abundant.

²¹ Faber and Proops (1991) estimate the share of rent in the price of coal in 1990 and find this to be 10.1%. This is low relative to the findings for oil and gas (at 54.2 and 57.9 respectively) but indicates that total rents would have been positive in that year.

ECOTEC (1993) estimated defensive expenditures in the UK to amount to about 3% of GDP in 1990 (half of which is accounted for by pollution abatement alone). Of this, government undertakes 94% of this expenditure. It is often suggested that these defensive expenditures be deducted from national accounting aggregates (Daly, 1989). As Bryant and Cook note, this should not be interpreted as conventional wisdom. It also yields a paradox in that a country that devotes more resources to, say, pollution abatement will have a lower level of GDP and NDP. However, abatement provides benefits over time in addition to the costs incurred in forgone consumption elsewhere and it is at least arguable that it might be treated as an investment in natural capital. Bryant and Cook seem to prefer to treat defensive expenditures as a proxy for environmental damage and then proceed to discuss the possible valuation of 'residual environmental degradation' - i.e. the value of damage that is not restored by defensive expenditures.

Environmental Resources Limited (ERL) (1992) Natural Resource Accounts for the UK, Department of the Environment, London.

Commissioned by the UK Department of Environment (DoE) to examine the potential use of natural resource accounts in the UK, this report develops pilot resource accounts for forestry, water and energy. Its remit was to consider international experience in this field, develop the aforementioned accounts and examine the potential for the development of satellite accounts to the SNA. ERL consider the uses of resource accounts to be the 'improvement of decision-making about natural resource and environmental management', 'provision of information on natural resources and their uses as inputs to analytical models used for economic and resource planning' and the improvement of 'measurements of national income and national wealth' (p2). In general, the perception is that the profile of

environmental issues would be raised, although the decision makers benefiting from this information are less clearly identified.²²

A regional approach is taken in the construction of water accounts, in order to reflect the spatial variability of water supply.²³ One of the uses of water accounts envisaged is the prediction of water shortages. The report claims that the lack of water stock data makes such prediction impossible.

Finally, the report notes that the construction of energy accounts has been particularly useful in the Norwegian context. ERL also express enthusiasm for this emphasis, not least because of the relatively abundant data for this sector. Various energy sources are considered. The Digest of UK Energy Statistics provides physical data on coal, oil and gas extraction and reserves, which this report lists in a time series. An extraction, conversion and use table is shown based on this physical information. The accounts are in physical form and there is no discussion of valuation. ERL clearly favor natural resource accounting in the Norwegian mode, arguing that this information can and has been used as a predictive instrument rather than just ex post summaries.

Lynch, R., and Brown, A., 1994, The National Accounts and the Environment - Developments in the United Kingdom, Central Statistical Office and Department of the Environment, meeting on National Accounts and the Environment, London, March 16-18, 1994.

²² For example, the report speculates as to whether the arrangement of existing data in an accounting framework would offer additional insight to resource managers.

²³ For example World Resources 1992-3 shows that annual internal renewable water resources (i.e. run-off) in the UK is 120.0 km³ of which 24% is used each year.

The UK government Strategy for Sustainable Development (as noted in Lynch and Brown 1994) states that resource and environmental accounts will be important in monitoring sustainable growth. Such green accounts could provide one of a number of indicators of the benefits and damage to the environment associated with economic change. While environmental accounts could provide objective, comprehensive and systematic information which is necessary if consideration of the environment is to become a central element in decision-making in government and industry, there are no plans to aim for a single environmental indicator or index.

Work on resource and environmental accounting has just commenced in the UK. The Central Statistical Office has published a review article on the topic (Bryant and Cook 1992), and the Department of the Environment has established a task force to examine options for work.

USA

Daly, H., and Cobb, J.B. Jr. (1989) For the Common Good, Beacon Press, Boston.

Nordhaus, W. (1992) Is Growth Sustainable? Reflections on the Concept of Sustainable Economic Growth. Paper presented to the International Economics Society, Varenna, Italy, Oct. 1992.

Nordhaus, W. and Tobin, J. (1972) Is Growth Obsolete? Economic Growth. Fiftieth Anniversary Colloquium V. New York: Columbia University Press.

The construction of welfare-adjusted measures of national accounts was the subject of several academic studies in the United States (Nordhaus and Tobin 1972, Daly and Cobb 1989, Nordhaus, 1992). Sustainability issues are presented in those studies as an attempt to provide more 'realistic' income measures. However, their results vary widely.

The first work was the Measure of Economic Welfare (MEW) presented by Tobin and Nordhaus (1972). The major differences between MEW and GNP are:

- imputations for the value of leisure time, household work and the services of government and consumer capital,
- deductions for government intermediate goods and 'regrettable necessities', private intermediate product, disamenities of modern life, capital consumption and growth requirements to equip new workers, and to provide a growing standard of living to future workers.

The results, covering the period 1929/1965, present a positive growth of per capita income but at a lower rate than NNP (Table 5).

Daly and Cobb (1989) used a similar rationale to create the Index of Sustainable Economic Welfare (ISEW): the conventional measures from the national accounts are adjusted by imputations and subtractions in order to provide an improved measure of social income based on the notion of sustainability. The main differences from MEW are in the treatment of non-market activity (ISEW omits the value of leisure), 'defensive expenditures' (ISEW omits health expenditures and investment), long-term environmental damages (arbitrarily determined in ISEW but not present in MEW), adjustment for income inequality and other corrections: auto accidents, loss of wetlands and farmlands and national advertising. There is also an adjustment for depletion of non-renewable resources: the total value of mineral production is subtracted. The series covers the period 1950/1986, and it shows a negative per capita output growth for the period 1965/1986 (Table 5).

In a more recent paper Nordhaus (1992) provides a third estimate, called 'Hicks

Table 5
Comparison Of Growth Rates Of Different Income Concepts
United States - 1950/1986

Income Growth	1950/1965	1965/1986	Growth Slowdown
Total Income Growth:			
ISEW	3.81	1.02	-2.79
MEW	2.07	na	na
Hicks Income No. 1	4.41	2.35	-2.06
GNP	3.75	3.05	-0.70
NNP	3.69	2.05	-1.14
Population Growth	1.63	1.05	-0.58
Per Capita Income			
Growth:			
ISEW	2.15	-0.03	-2.18
MEW	0.43	na	na
Hicks Income No. 1	2.74	1.29	-1.45
GNP	2.09	1.98	-0.11
NNP	2.03	1.85	-0.17

Source: Nordhaus (1992)

Income No. 1'. It is an attempt to construct a sustainable income measure derived from Hicks' definition (Hicks 1939). The results from Daly and Cobb (1989) are used with several changes, excluding arbitrary or theoretically incorrect entries and replacing some estimates with figures obtained from Eisner (1989). The results show that 'Hicks Income No. 1' growth is always positive, slightly higher than GNP and NNP in the 1950/1965 period, and slower in 1965/1986 (Table 5).

Prince, R. and Gordon, P.L. (1994) "Greening the National Accounts", Congressional Budget Office, Washington DC.

The empirical section of this study presents estimates of total rents from the depletion of oil in the US from 1981 to 1990. For the same period, the value of degradation of air and water quality is also estimated.

Total rents are calculated using a formula proposed by Hartwick and Hageman (1993). This differs from that originally proposed by Hartwick (1990). Rather than valuing

discoveries at their full rental rate, Prince and Gordon net out from the usual 'rent times units of the resource depleted' calculation, the (marginal) cost of discovery multiplied by the units discovered - this parallels the adjustment for discoveries derived in Hamilton (1993). The results are not related to an estimate of 'green' NDP. The value of oil depletion in the US varied from 2% of GDP during the first half of the 1980s to less than 1% of GDP in the remainder of the decade.

By relating changes in environmental indices to the costs of abatement the environmental degradation of air and water quality is valued - i.e. how much would it cost to maintain last years level of environmental quality. While it would appear that on average both air and water quality - as measured by the indices - improved from 1981 to 1990, significant values for degradation are nonetheless obtained. The total value of environment degradation remains fairly constant at about 1% of GDP throughout the 1980s.

Bureau of Economic Analysis, 1994a, Integrated Economic and Environmental Analysis, press release, BEA 94-20.

Bureau of Economic Analysis, 1994b, Integrated Economic and Environmental Analysis, Survey of Current Business, April 1994.

Bureau of Economic Analysis, 1994c, Accounting for Mineral Resources: Issues and BEA's Initial Estimates, Survey of Current Business, April 1994.

The Bureau of Economic Analysis (BEA) published its first Integrated Economic and Environmental Satellite Account (IEESA) in 1994. According to the press release announcing the publication (Bureau of Economic Analysis 1994a) the accounts were designed to: (i) examine the effects of changing patterns of demand on natural resource use; and (ii) support the analysis of the effects of changing resource costs and availability on the suppliers and users of natural resources. The BEA had published accounts of environmental protection expenditures since the mid-1970's. The IEESA incorporated these data as well as new estimates of the value of subsoil reserves and flows into a framework similar to the United Nations' SEEA (United Nations 1993b).

The article in the Survey of Current Business presenting the new accounts (Bureau of Economic Analysis 1994b) deals with the range of analytical questions they were designed to examine. These include questions concerning what is the rate of natural resource use, what is the economic return to mineral stocks in the extractive industries, and to what extent have resource additions (discoveries and revisions) matched depletion. The environmental protection expenditure components of the accounts were designed to examine the share of the cost burden borne by households, governments and business, and may ultimately speak to what are the costs of environmental

degradation, and by which sectors are these costs borne.

The article dealing with sources and methods for the accounts (Bureau of Economic Analysis 1994c) addresses policy uses more directly. One such use is in identifying over-exploitation, for example of mineral resources on public lands, or the New England fishery. Another set of uses revolves around the productivity analysis of the resource sectors, and the concomitant effects on the overall productivity of the economy. Finally it is noted that the lack of accounts of resource stocks and their changes on Federal lands has led to "less than optimal" budgeting decisions by the Federal government.

It is expected that the IEESA will be expanded to include the value of stocks and flows of living resources, once new funding is secured.

Zimbabwe

Adger, W.N. (1993) Sustainable National Income and Natural Resource Degradation: Initial Results for Zimbabwe, in Turner, R.K. (ed.) Sustainable Environmental Economics and Management: Principles and Practice, Belhaven Press, London.

This study estimates the rents from deforestation in Zimbabwe in 1987, soil erosion in 1990 and mineral extraction for the last quarter of 1990 and the first quarter of 1991. The relevance of national accounts adjusted for resource depletion is claimed to be of particular importance in developing economies where there is a high dependence on primary production.

Fuelwood is a major source of energy in Africa and the assessment is that Zimbabwe has a fuelwood deficit (Hosier, 1986). Demand outstrips supply and hence a rent might be expected to accrue to these dwindling forest resources. In 1987, the net stock reduction was 2.66 million tonnes. An estimate of the extraction costs was imputed

from estimates of the minimum agricultural wage. This gives an estimate of average costs, where in the event of increasing effort required to search for fuelwood we would expect marginal costs (MC) to exceed average costs (AC). Subtracting AC from the market price of fuelwood in 1987, gives an estimate of depreciation (rent). The value of this depreciation was ZM\$ 93.77 (9% of agricultural GDP).

The value of soil erosion has previously been estimated using either the measurement of lost productivity or replacement costs of lost nutrients. Adger estimates soil erosion using the former (for example see Bishop, 1989). Assuming that soil conservation measures reduce erosion below the level of natural replacement and contribute to observed incremental yield, then the difference in the estimated gross margins on the conserving and non-conserving farms gives a cost of erosion. Estimates of ZM\$203.23 million for lost maize and cotton production were with the estimated forestry rent, depreciation of natural capital in 1987 was equivalent to

nearly 30% of agricultural GDP (5% of aggregate GDP).²⁴

Calculation of rents in the mineral sector highlighted the variability of these measurements. In the last quarter of 1990 rents were 20% of traditionally defined sectoral net product (gross profits less depreciation of man-made capital). In the first quarter of 1991 these amounted to 27% of sectoral net product. A production boom stimulated by the devaluation of the Zimbabwe dollar is given as the main reason for this increase - i.e. 1991(Q1) adjusted net product was over 7% greater than 1990(Q4) in contrast to traditional net product which grew over 18% over the period.

In terms of the uses of these adjustments, improved resource management is stressed, as are macroeconomic policy and sustainability issues in general. Data problems are emphasized, suggesting that the implementation of SEEA to a wider range of developing countries will prove complex.

²⁴ The value of depreciation on man-made capital in the agricultural sector was about 6% of agricultural GDP.

5 Conclusions

Still in its development phase, natural resource and environmental accounting is a field with important implications for policies for sustainable development. As governments attempt to match their actions to their rhetoric on achieving sustainability, the importance of environmental accounting will grow.

The development and use of environmental accounting will not be a uniform process across countries. Many developed countries have sophisticated models that permit the integration of resource and environmental information into macroeconomic analysis. For these countries the usefulness of adjusting national accounts aggregates may be limited, largely because policy simulations can be carried out directly. The *physical* natural resource and environmental accounts described above can support the implementation of these models.

Building complex policy models may be an expensive luxury in many developing countries, however. For these countries, rapid assessments of resource depletion and the value of environmental degradation, placed in the savings and wealth framework presented above, will guide policy-makers aiming for sustainable development. Green national accounting aggregates, including national income and genuine savings, place natural resources and the environment in an economic context that is otherwise lacking in developing countries.

There is by now a large and growing body of published work on green accounts, as both developed and developing countries have experimented with the construction of integrated environmental and economic accounts. The UN System of Environmental and Economic Accounts will prove useful in standardizing the structure of these accounts. While the published work reflects a wide variety of approaches to constructing accounts, this sort of experimentation is healthy in any developing field.

Of the range of *satellite* accounts described above, it is likely that the resource use and pollution emission accounts, tied to the Input-Output accounts, will have the most direct policy relevance, at least for richer countries. These accounts can feed into a variety of macro, general equilibrium and I/O impact models to enhance the analysis of resource and environmental issues, and to design policy responses. Natural resource accounts are, in addition, likely to be important for resource-rich nations concerned about sustainable development.

While physical accounts on resource and pollutant flows will have policy uses, the greatest potential for the integration of economic and environmental concerns lies in the development of new, greener, national accounting aggregates. Of these aggregates, measures of genuine savings will have greater policy relevance than 'green GNP.'

The policy questions that are raised by the analysis of genuine savings go far beyond the obvious admonition to save more and consume less. A wide range of policies affecting the exploitation of natural resources

and the emissions of pollutants to the environment is directly relevant, in addition to the more traditional elements of monetary and fiscal policy as they affect public and private saving and investment behavior.

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