Natural Resource Accounting and Sustainability

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Abstract

The recent emergence of concern for sustainability, or sustainable development, has lead to a renewed interest in the adequacy of national income accounts for monitoring economic performance. It has been argued that natural resource accounting is needed, and that national income accounting conventions need modifying. The paper reviews this background and argument, and distinguishes several types of natural resource accounting. It is noted that adjustment of measures of national income requires valuation, and that with respect to sustainability objectives market and surrogate market prices are inappropriate. It is argued that the pursuit of sustainability requires modelling rather than historical accounting. Some recent, unofficial, attempts at revising national income data to reflect sustainability concerns are critically reviewed. Finally, data requirements for ecological sustainability are considered.

1. Introduction

This paper attempts to give an overview of the extent to which natural resource accounting can promote the pursuit of sustainable development,

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and makes some suggestions as to how such pursuit might best go forward in Australia. It is written from the perspective of economics rather than that of national income accounting.

The paper is organised as follows. Section 2 considers the origins of an interest in natural resource accounting in a concern to promote sustainability. The term natural resource accounting is used interchangeably with environmental accounting, and both are used to refer to several distinct types of activity. These matters are considered in Section 3 of the paper. Section 4 discusses current activities of relevance both internationally and in Australia. The central problem, in the desire to adjust national income figures to reflect sustainability considerations, that of valuation, is discussed in section 5. It is noted that the approach to this problem that has been adopted to data is to seek to use market and surrogate market valuations: some results arising are considered in Section 6. Section 5 notes that an alternative approach, in principle, to valuation would be via explicit consideration of social objectives in the light of perceived constraints. Section 7 of the paper discusses the data requirements arising from an ecological approach to sustainability.

The final section of the paper draws some conclusions and makes some recommendations. The overall thrust of the conclusions is that, while there is a clear need for more information on economy-environment interactions, the apparently widespread view that resource and environmentally adjusted national income accounting represents an important part of a strategy for sustainable development is misconceived.

2. National Income Accounting and Sustainability

The idea of sustainable development was popularised by the Brundtland report (World Commission on Environment and Development, 1987), where the basic definition (p. 43) is that:

> sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The basis for the implied concern with the possibility that current economic activity could damage future prospects lies in economy-environment interactions. Essentially the Brundtland report argues that such interactions represent threats to sustainability, which need to be addressed by policy. It states (p. 52) that:

> In all countries, rich or poor, economic development must take full account in its measurements of growth of the improvement or dete-

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rioration in the stock of natural resources.

In this context the point of departure for an interest in natural resource accounting is the fact that no country now does this. The presumption is that resource stocks are generally deteriorating, and that proper accounting would reduce measured growth rates. An additional question that proper accounting appears to be thought capable of addressing is whether properly measured growth is sustainable.

Referring to current national income accounting practices, Repetto *et al* (1989, p. 4) claim that:

> A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife to extinction, measured income would not be affected as these assets disappeared.

Here measured income is GDP and Repetto *et al* take the view that 'politician, journalists, and even sophisticated economists in official agencies continued to use GDP growth as the prime measure of economic performance'. They argue (p. 19) that it is 'Only if the basic measures of economic performance ..... are brought into conformity with a valid definition of income will economic policies be influenced toward sustainability'. Repetto *et al* (1989) have attempted to construct improved income measures for Indonesia: this work will be discussed in Section 6 below.

Daly and Cobb (1989) also take the view that the influence on policy makers of conventional measures of national income, such as GDP, is the source of much damage to the natural environment, and also to human welfare. In their view, the availability of even imperfect alternative measures of economic performance would lead to improved policies with respect to sustainable development. They have calculated such a measure for the USA, and call it the Index of sustainable Economic Welfare, ISEW. In respect of it, they:

> ... believe that it is urgent to replace the GNP with a measure that does not encourage the growing gap between the rich and the poor and that discourages unsustainable economic practices. The ISEW is far from perfect ..... but the difference in policies ordered to the improvement of the ISEW and those ordered to use improvement of GNP would be considerable, and they would help to buy the time for the deeper changes that are needed.

The ISEW work of Daly and Cobb will also be discussed in Section 6 below.

In Australia the federal government has established a process intended to advise it on how to promote sustainable development. This is widely known as the "ESD", for ecologically sustainable development, process. It was initiated in June 1990 with the publication of a discussion paper

(Commonwealth of Australia, 1990) which briefly addressed national income accounting issues. Australia's four major environmental organizations responded with a commentary (Hare, 1990) in which the views of Repetto et al (1989) and Daly and Cobb (1989), reported above, in regard to national income accounts and sustainability are endorsed. It is stated (Hare, 1990, 13), for example, that:

> The current reliance on simplistic measures such as Gross National Product per capita is inappropriate and is currently providing incorrect signals to decision makers in relation to sustainability objectives.

The basis for these sustainability driven critiques of conventional national income accounting practices can be amplified and illustrated by means of the numerical example provided in Table 1. The data has been constructed to bring out the issues of concern in the context of this paper. Many aspects of national income accounting, for example, the treatment of foreign trade and the income as against expenditure approach to measurement, are ignored.

Table 1: *Physical Changes and National Income Accounting*

1. Flows	**Period 1**		**Period 2**
Consumption	15		20
Investment	15		15
Labour	100		100
Kapital	10		100
Oil	5		6
Timber	10		7
Wastes	10		11
2. Stocks			
Kapital	100	$SK_2 = SK_1 + I_1 - D_1$	105
Oil	100	$SO_2 = SO_1 - O_1$	95
Timber	1000	$ST_2 = ST_1 - T_1 + G_1$	995
Wastes	100	$SW_2 = SW_1 + W_1 - A_1$	105

3. National Income

$GNP_t = P_{ct}C_t + P_{It}I_t$

$Y_t = P_{ct}C_t + P_{It}(I_t - D_t) = NNP_t$

$Y_1 = 150 + 20 = 100 + 70 = 170$

$Y_2 = 160 + 20 = 110 + 70 = 180$

$Y_2/Y_1 = 1.0588 \quad C_2/C_1 = 1.0667$

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The economy to which Table 1 refers produces one consumption good and one investment good. Production uses inputs of labour and the services of man-made capital equipment, together with oil and timber. Wastes necessarily arise in production and consumption, and are discharged into the environment. The various physical flows for two consecutive periods are shown in part 1 of the table.

Part 2 shows the physical stocks corresponding at the beginning of each period. Also shown, between the data, are the stock-flow relationship determining stocks at the beginning of the second period. The notation here uses the appropriate initial letter for a flow and prefixes with an S to indicate the corresponding stock (Kapital is used to avoid C here as C is conventionally used, as here, for Consumption). A subscript dates flow and stock variables. The stock of Kapital at the start of period 2 is the original stock plus investment, I less depreciation, D, which is the flow of services during period one, shown in part 1. Oil is a non-renewable resource, so that the stock at the beginning of the second period is the original stock less use during the first period. Timber is a renewable resource so that G_1 appears in the third equation to indicate natural growth during period one: G_1 is equal to 5. The flow of wastes adds to the stock which is subject to naturally occurring decay: A_1 represents the assimilation of waste during period one, amounting to 5 units.

Part 3 of Table 1 shows elements of the national income accounts for this economy for period one, on current accounting conventions. GNP stands for Gross National Product, NNP for Net National Product (for present purposes the National/Domestic distinction is irrelevant - GNP could just as well be GDP, and NNP be NDP). The former is the sum of the values of the consumption and investment flows, where P_{Ct} is the price per unit of the consumption good and P_{It} is the price per unit of the investment good. NNP is GNP less the value of the depreciation of the Kapital stock in producing consumption and investment goods. It is universally agreed that NNP is the national income measure which is appropriate for measuring growth and making international comparisons, and it is conventionally given the symbol Y. If production did not involve natural resource depletion and waste accumulation, it would be a Hicksian income measure. It would be the largest amount, in value terms, that could be consumed without running down the value of the economy's productive assets, its wealth. While it is agreed that national income should be measured net, and national income accounts do report NNP, much quantitative description and analysis is based on the gross measure GNP. This is because the gross figures are generally regarded as more reliable due to the difficulties of measuring and valuing depreciation of man-made capital in

practice.

It is useful to distinguish two basis for the sustainability critique of current national income accounting practices. What may be called the "production measurement" basis is the contention that Y does not measure sustainable income by virtue of ignoring natural resource depletion and waste accumulation. This is the basis for the critique of Repetto *et al* (1989) cited above. The "welfare measurement" basis is that, anyway, changes in Y do not measure changes in human welfare. This argument is used, in addition to the first one, in the environment groups' commentary (Hare, 1990) on the Commonwealth discussion paper (Commonwealth of Australia, 1990) which initiated the ESD process as described above. The particular argument is that included in the flows of consumption and investment goods, which are summed to give national income before depreciation, are goods being used to offset the harmful effects of accumulated wastes stocks, ie of environmental pollution. Expenditures on such goods are called defensive expenditures, and it is argued that these do not contribute to welfare and should not be included in the measure of Y. Daly and Cobb (1989) use this particular argument and others coming under the general heading of 'welfare measurement' (see Section 6 below for further discussion).

This distinction is important for several, closely related, reasons. First, if not kept in mind confusion can arise in discussing natural resource accounting. Second, it indicates that for some at least of the critics of current national income accounting the agenda involves not merely improving performance in regard to existing criteria but also changing that which is being measured. Third, at the conceptual level the "production measurement" basis gives rise to relatively little difficulty, while the "welfare measurement" basis raises some very difficult problems. Few economists would disagree with the proposition that, in principle, the net national income measure should allow for depreciation and accumulation of all stocks relevant to production. There is, however, disagreement over whether defensive expenditures should be netted out of Y. this will be discussed further in Section 5 below.

It is convenient to leave aside the defensive expenditures question, and to assume that stocks are relevant only to production, so as to focus on the production measurement issue in relation to sustainability. The data in part 2 of Table 1 here show that period one economic activity results in declines in the stocks of both oil and timber, and an increase in the stock of wastes. Taken alone, these changes reduce the stock of productive assets and longterm production capability. However, the stock of man-made Kapital is increased by period one activity. The question which arises is whether

this increase offsets the decreases. The answer depends upon the possibilities for substitution as between inputs to production. Clearly, if say oil is essential in production and cannot be substituted for by Kapital, then a reduction in the stock of oil reduces future production capacity and the income level realised in period one is not indefinitely sustainable. Indeed, in this extreme case no positive income level would be indefinitely sustainable: for further discussion of the issues see Chapter 7 of Common (1988) or Dasgupta and Heal (1974).

The point here is that knowledge of what has happened to the various stocks over the period is not knowledge about whether economic activity in the period is sustainable. The latter requires also knowledge about substitution possibilities in production. The view that a new approach to national income accounting will itself promote sustainable development appears to involve the view that it will reveal information on substitution possibilities in production. This is discussed in Section 5 below.

It is not the case that all criticism of, or arguments for modification of, national income accounting derive from a concern with sustainability, and postdate the publication of the Brundtland Report (World Commission on Environment and Development, 1987). In 1972, for example, revised accounts were calculated (unofficially) for the USA which recognized that a growing population itself generated a need for capital widening, subtracted from measured income some defensive expenditures such as commuting and policing costs, and made imputations for leisure and non-market work (Nordhaus and Tobin, 1972). Zolotas (1981) also worked with US data, but took as a base in the published accounts consumption rather than income, and made allowance for resource depletion. Usher (1980) has revised official Canadian accounts data with various imputations and deductions, including adjustments in respect of resource depletion. Some work in the spirit of Nordhaus and Tobin was done in Japan in the early 70s (see Pearce et al (1989) for discussion and some results, and also Peskin with Lutz (1990)).

3. Variants of Natural Resource Accounting

It is necessary to consider this question since the term is used in several different ways and to describe a number of quite different types of activity. Also, it should be noted that the term 'environmental accounting' is sometimes used interchangeably for natural resource accounting: (see, for examples, Pearce *et al* (1989) and Ahmad *et al* (1989)). At one extreme these terms are used to refer to any activity which involves providing data on some aspect of economy-environment interaction. At the other the

reference is to the provision of some adjusted national income type measure of economic performance. These differences in terminology can generate confusion.

Most generally we can say that the term natural resource/environmental accounting means the collection and publication of data on the state of the natural environment as it relates to human economic activity, where the organisation of the published data follows the same lines as that used for economic data itself. This last qualification is introduced to distinguish natural resource/environment accounting from the compilation and reporting of "environment indicators" or environmental statistics". This activity is also sometimes referred to as "state of the environment reporting". In it, information on the environment is seen as interesting in its own right and the data is not organised along the same lines as economic data. the distinction made here, between natural resource accounting and state of the environment reporting, is not always clear-cut, but it is useful. While no official natural resource accounts have appeared in Australia, there have been efforts toward state of the environment reporting: see for example Department of Arts Heritage and Environment (1987) or MacRae (1987). Environment indicators in relation to sustainable development are discussed in Section 7 below.

So defined, natural resource accounting can take a variety of forms, as can be explained in terms of Table 1 here. A first step would be *Physical Stock Accounting*, where the opening and closing stocks of resources and waste shown at B are measured and reported. The stock changes imply the corresponding flows in natural growth, in Timber, and assimilation, for Wastes, are known. Given the same knowledge, stock changes can be inferred from the physical flows, and the closing stock derived from the opening stock if that is known. It is worth noting that data on physical flows of resource inputs is likely often to be routinely recorded by private agents, while they will frequently lack the incentive to record waste flow. Even at the level of abstraction involved here, it is clear that in regard to wastes, establishing definitive physical stock accounts will involve effort additional to that routinely expended by private agents at the level of primary data provision. Also, with regard to renewable resources, one would expect that the extent to which private agents can be expected to generate primary data, on G particularly, will vary with the property rights situation. Even where reliable physical primary data on renewable and non-renewable resource stocks and/or flows exists, there remains the task for the public sector of collecting processing and publishing it. The point is that the simple format of Table 1 should not be allowed to give the impression that the generation of physical stock accounts is either trivial or costless.

If prices exist for units of oil, timber and waste (negative), and physical stock accounts exist, then the latter can be converted to *Value Stock Accounts*. For each environmental asset an opening and closing value figure could be provided. Further, prices would permit of aggregation across environmental assets, and of total environmental asset value with Kapital value. A figure for opening and closing total asset value, or wealth, would be available. Some definitional difficulty arises here. Would one want a measure of total wealth to include or exclude the negative value of the pollution stock of accumulated wastes? As regards productive potential in Table 1, waste accumulation is either irrelevant or, if it affects the growth of timber, already accounted for. This might suggest that it should be excluded from the total wealth measure. On the other hand, if increasing levels of accumulated wastes are perceived as undesirable by households they reduce the welfare associated with any given level of consumption, and so should be accounted for in a single measure of asset valuation according to some commentators (see, for example, Peskin in Ahmad *et al* (1989)).

If prices are available so as to permit of value stock accounts, then it would seem that an *Adjusted Net National Income Account* can be readily be constructed to deal with the problems with the conventional measure introduced in the previous section. There national income was defined from the expenditure/production side as:

$$Y_t = P_{Ct}C_t + P_{It}(I_t - D_t)$$

and a straightforward extension would be:

$$Y_t = P_{Ct}C_t + P_{It}(I_t - D_t) - P_{Ot}O_t + P_{Tt}(G_t - T_t)$$

which accounts for total net depreciation as it affects productive capacity. As noted above, there is also the matter of pollution affecting the amenity that households enjoy. If net national income is to be regarded solely as a production type measure, further adjustment to it on pollution grounds is inappropriate. Rather, it would then be more appropriate to adjust the consumption measure itself as:

$$AC_t = P_{Ct}C_t - P_{Wt}SW_t$$

and to keep separate national income as a production measure from adjusted consumption, AC, as a welfare measure.

Four possible purposes for generating and reporting data on economy environment relations can be distinguished:

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(i)The provision of an historical record of human use of the environment

(ii)The improvement of understanding of the relationships between the state of the environment and its ability to satisfy human needs

(iii)The creation of an improved ability to manage for human purposes the total system comprising the economy and the environment

(iv)The creation of a single indicator of economic performance such as adjusted net national income which, unlike national income, accounts for the environmental impact of economic activity.

The attainment of the third objective here would subsume the attainment of the first two - an historical data set would be necessary for improved understanding, itself necessary for improved management. Attainment of the third objective would necessitate modelling economy-environment relationships. It would permit of definition and measurement of a variety of performance measures. It would not essentially involve valuation, and data serving the first three objectives would be in physical terms ideally. The fourth objective, on the other hand, necessarily involves valuation, and, as will be discussed in Section 5 below, in current manifestations involves a particular basis for such valuation. Pursuit of the fourth objective would not necessarily promote the attainment of the third.

4. The Current Situation

At the present it does not appear to be the case that any country is producing officially either value stock accounts or adjusted net national income accounts as defined above. Some unofficial efforts in the latter direction are described and discussed in Section 6 below.

The guidelines accepted by official statistical agencies for national accounting are set out in *A System of National Accounts*, widely known as "the SNA", published by the United Nations in 1968 (UN, 1968) and in a subsequent publication (UN, 1977), widely known as M60. These guidelines are mainly concerned with what is here called Kapital, but do cover some natural resources. Few countries have made much progress in the production of balance sheet and reconciliation accounts. It is now widely recognized that the guidelines are in need of revision for a number of reasons including inadequate treatment of the environment and natural resources.

Such revision is currently the subject of much activity in official national accounting circles (see, for example, Ahmad *et al* (1989)). These are explicitly founded in a concern to promote sustainable development. They involve the development of *Satellite Accounts* covering natural resources

and the environment, aligned with SNA conventions, and capable of being linked to the national income accounts so as to permit of adjustments thereto. The Bartelmus *et al* (1989) framework follows that of the existing SNA as closely as possible, so that its adoption would not preclude the concurrent continuation of national income accounts in their present form. This is an important desideratum given the many purposes for which current national income measures are seen as useful, and for which consistent time series are needed. Any proposal which implied that in future there would not be available national income data in its current form would stand little chance of acceptance by national income statisticians and economists who advise governments and international agencies such as the UN and World Bank.

The basic idea of Bartelmus *et al* (1989) involves two new sets of accounts. In the first, dealing with flows of goods and services, those flows which relate to environmental protection, often referred to as defensive expenditures, are separated out from all other flows to final demand. Given this separation, a measure of *Environmentally Adjusted GDP* arises when defensive expenditures are subtracted from GDP as conventionally calculated. The second new set of accounts concerned stocks of natural resources and environment assets, and consists of opening and closing balance sheets in value terms, together with two tables linking these in terms of physical and unit value changes over the period. Then, *Environmental Cost* is defined as the difference between the value totals for the two balance sheets, ie the change in the value of natural resources and environmental assets over the period. *Sustainable GDP* is then defined as Environmentally Adjusted GDP minus Environmental Cost. Then *Sustainable NDP* is defined and measured by subtracting from Sustainable GDP the deprecation of the man-made capital stock, Kapital. Note that the procedures by which Sustainable NDP is arrived at do not render un-available any of the conventional national income measures, nor do the measures change. Inconsistencies are accommodated in the satellite accounts.

In October 1990 UNSO produced a "preliminary draft" of Part 1: General Concepts for an *SNA Handbook on Integrated Environmental and Economic Accounting* (UN, 1990). This has recently become available in Australia. It appears to follow the general lines of Bartelmus et al. It is stated to represent "work in progress", and comments and discussion are sought.

Clearly there has as yet been no actual implementation of the framework proposed by Bartelmus et al the official level, and as far as is known not at the unofficial level either. The paper itself uses illustrative numbers from a "desk-study" for a single year, in a similar manner to Table 1 here. It

follows that commentary on the actual implementation of the proposals is now impossible. It appears that UNSO is planning some pilot studies on the implementation of the proposals. Peskin with Lutz (1990) discusses the proposals as set out in the original paper and draws attention to some potential problems and deficiencies. These mainly concern the treatment of defensive expenditures. He notes a possibility for double counting of some such expenditures, and that another possible problem

> is the failure to distinguish between services provided to economic sectors by the environment and damages (or 'costs') to the environment by these sectors. The single 'environmental cost' entry implies that these values are the same. More, if, as the authors suggest, these damages are to be valued in terms of their cost of elimination, it implies that the opportunity cost of environmental policy is exactly equal to the policy benefits. These assumptions make it impossible for the authors to use their framework for an 'assessment of environmental costs and benefits' - one of their stated objectives.

UNSO's interest in matters environmental has not been confined to natural resource/environmental accounting as defined here, but has also extended to environmental indicators, or statistics, as defined here. It has published *A Framework for the Development of Environmental Statistics* (UN, 1984) and a draft report on Natural Environment Statistics is currently being considered by workshops. The Framework document uses the media and stress response approaches to organising data about the environment. Neither of these necessarily aligns with economic accounting data. The media approach organises according to the air, land/soil, water, and man-made classification. the stress response approach focuses on the transformation of the natural environment - response - taken to be caused by human activity - stress.

In Australia, the Australian Bureau of Statistics (ABS) recently published a very useful statement of its views in *Natural Resource and Environmental Accounting in the National Accounts.* The article concludes as follows (ABS, 1990a, p. 71):

> The ABS is taking a close interest in developments in environmental and natural resource accounting and it recognizes the growing need for a comprehensive means of assessing whether or not the current rate of economic development is sustainable in the longer term. The ABS is planning to investigate the emerging statistical requirements in this area and to put further effort into improving the statistical measures available on Australia's natural resource and environment.

An earlier manifestation of interest in these matters in Australia is an

Australian Environment Council Report (Australian Environment Council, 1984).

What are here called value stock accounts are more conventionally known as balance sheets. The ABS article points out that the existing UN guide-lines for national accounting referred to above specifically cover the preparation of balance sheets where the asset coverage includes some renewable and non-renewable resources. It discusses some of the problems associated with the existing UN guide-lines, and notes "the fact that most countries have not yet fully implemented the balance sheet guide-lines, particularly in respect of natural resource". With respect to Australia, it is noted that (ABS, 1990a, p. 66):

> Considerable valuation problems would have to be resolved before Australia could produce a full set of balance sheet and reconciliation accounts. At present, Australia does compile two important elements of balance sheets, namely stocks of fixed assets and the international investment position. However, the former refers to "human-made" rather than natural resource assets and the latter is restricted to financial claims between Australia and the rest of the world.

The position taken by the ABS in this article is that natural resource accounting is best approached in terms of satellite accounts. Essentially this involves the preparation of what have here been called physical and value stock accounts for natural resource and pollution. The latter are not, however, to be used to produce an adjusted net national income account as the single measure of economic performance. Rather, the existing national income accounts will continue to be produced, together with adjusted figures based on modifications using the data from the satellite accounts. The view is that the existing accounts are well established and useful for many purposes, so that it would be unwise and premature to replace them with adjusted measures of doubtful reliability.

Also relevant to future natural resource/environmental accounting activity by ABS is the establishment within its Agriculture and Mining section of an Environment and Natural Resource Statistics Unit in late 1990. It is envisaged that it will have two principal functions. One is to work toward a capability to provide physical data as the basis for the satellite accounts referred to above. The other is to work on the compilation and publication of environmental indicators. In regard to the latter the unit is planning to publish a document containing environment statistics for Australia, which is likely to follow the UN guidelines on environmental statistics mentioned above (UN, 1984) to some extent. The unit has already been involved in discussions with various government agencies concerned with data collec-

tion and use. Its activities and plans are discussed in a paper prepared for a September 1990 meeting of the Statistical Institute for Asia and the Pacific (ABS, 1990b).

There are a number of other Australian activities which relate to natural resource/environmental accounting:

(i)The National Resource Information Centre, NRIC, was established, in DPIE, in May 1988. NRIC's mission is to improve the information base for drawing up policy and making decisions about natural resource use issues. This involves improving access to existing and prospective data sets elsewhere - in other Federal agencies, in State government departments, and in non-governmental organisations such as universities and research institutes - rather than in-house data compilation and publication. NRIC has developed FINDAR (Johnson and Robey, 1990) which is a directory system involving linked nodes to enable users to find out what natural resource and related information exists where. This system is now operational and should facilitate better use of existing data on natural resources.

(ii)The creation of the Environmental Resources Information Network, ERIN, was announced in the Prime Minister's 1989 environmental statement with the brief to "draw together, upgrade and supplement information on the distribution of endangered species, vegetation types and heritage sites". ERIN is a program within DASETT and the ERIN unit is part of the Australian Biological and Environmental Survey within the Australian National Parks and Wildlife Service. It is envisaged that ERIN will create a directory of sources of environmental information to complement the "resource-focussed data basing activities of ... NRIC". ERIN's main project during its initial phase (to mid 1992) is to be the construction of a Geographical Information System of the Australian continent focussing on the biological environment. (Information and quotes from a flier of mid 1990).

(iii)The National Forest Inventory, NFI, project is administered jointly by DPIE and DASETT. The NFI is being compiled through NRIC: it is a three year project covering all forested land tenures. It is envisaged that NFI will cover the following attributes: forest diversity; flora and fauna, including rare and endangered species; sustainable wood production capacity; wilderness value; tourist usage; water catchment capacity. (Information from a flier dated May 1990).

(iv)The Resource Assessment Commission, RAC, is surveying State Forestry departments/commissions and the National Parks and Wildlife Service on a wide variety of forest related matters. NRIC has been contracted to provide analysis and presentation of the data arising from the survey. (Information supplied by RAC).

(v)Within DPIE a number of units generated and compile time series data on production flows and resource stocks, notably the Bureau of Mineral Resources and the Australian Bureau of Agricultural and Resource Economics.

This is no doubt an incomplete record of the full range of data generation and compilation activities in Australia which are relevant to natural resource accounting in its various forms. It does, however, indicate the range of agencies involved in natural resource and environmental data activities, and suggests the need for some co-ordination if increased activity is to be conducted cost effectively. It also indicates a focus on physical data. The next section of this paper argues the case for economy-environment modelling to promote sustainable development. The ORANI model is currently being used in the ESD process, and a new version of it is planned to include detailed representation of economy-environment interactions (Dixon and Parmenter, 1991). Ideally, data related and modelling activities would proceed in a co-ordinated interactive manner.

5. The Valuation Problem: Two Approaches

Hicksian income is the maximum that can be consumed within a period without reducing wealth, where wealth is the value of the asset portfolio. As discussed in Sections 2 and 3 here, the motivation for natural resource accounting to produce Adjusted Net National Income can be interpreted as the desire to measure Hicksian income with the asset portfolio expanded to include natural resource and environmental assets. Given this, the role of relative prices, of valuation, is clearly crucial. Such prices or values are necessary for aggregation across different assets, which aggregation is necessary for the measurement of wealth, and hence for the measurement of Hicksian, or sustainable, income. It is equally clear that the valuation problem involves looking forward in time - it is an intertemporal problem. Current asset values are to be derived from their contributions to future consumption.

An idea closely related to that of Hicksian income is the "Hartwick rule" (Hartwick, 1977; Solow, 1988). This rule was initially developed in regard to non-renewable resource depletion but has since been shown to apply

where these and renewable resources are used in production. It says that in an economy using natural resources in production, constant consumption over time requires that the resource rents arising along efficient use paths be invested in reproducible Kapital. This is requivalent to requiring that the value of the entire asset portfolio, including natural resource stocks and Kapital, be held constant. The condition is necessary but not sufficient - if a resource is essential in production in that it is not possible to replace its services within those of Kapital, then clearly there is no Kapital accumulation programme that can avoid the implications for production and consumption of depleting the resource. Clearly, relative prices and valuation play a crucial role in the Hartwick rule. In fact, the rule ensures that relative prices will measure wealth correctly by the requirement that it is the rents associated with efficient resource use paths that are invested in Kapital. As a resource stock is run down so the efficiency rent per unit rises, so that the role ensures that investment in Kapital increases as resources are depleted.

Consider an economy which has no connections with the natural environment, and where the only assets are stocks of Kapital equipment. Assume also that there is just one consumption good, or that problems of aggregating over consumption goods have been solved. The remaining problem is aggregating over consumption and investment by the proper pricing of investment with consumption as numeraire. This is a dynamic optimization problem in as much as investment is to be valued today in terms of its contribution to consumption tomorrow. Weitzman (1976) has shown that he proper price on investment in terms of consumption is the shadow price emerging from the maximization of the sum of discounted consumption into the indefinite future subject to the consumption possibility set constraint given by saving and investing. Given the use of this price, wealth is the discounted value of future consumption, and Hicksian income is the flow which is the interest rate rental on that wealth. Net national income "is what might be called the *stationary equivalent of future consumption*' (Weitzman, 1976, p. 160, italics in the original). This paper shows that, given the correct pricing of investment and Kapital, net national income and wealth are just different ways of looking at the same thing, and net national income is a proxy for the present, discounted, value of future consumption. The qualifying "correct pricing" is of course crucial.

A rigorous approach to measuring net national income and wealth where production and consumption involve the use of natural resources and environmental assets will be an extension of the Weitzman approach to include such assets. A theory of natural resource accounting for adjusted net national income purposes will require, that is, to be based in analysis of constrained intertemporal optimization where the constraint set includes

resource use and growth equations as well as equations describing production and Kapital accumulation. To date there appear to be just two contributions to the literature on natural resource accounting that fall into this category. Faber and Proops (1990) use a numerical example to discuss some of the issues arising, and argue that shadow prices from an intertemporal optimization exercise are necessary for consistent accounting.

Maler (1990) uses the same mathematical techniques as Weitzman to analyse a model which has renewable resource used in production and affecting household utility, wastes arising in production and affecting environmental quality, and where labour, Kapital, and produced output can be allocated to environment quality improvement instead of to production for consumption. Maler shows that the basic Weitzman result carries through into this extended context, and that the Hartwick rule applies, *given pricing using the shadow prices derived from the constrained optimization.* Maler also derives a number of particular results concerning the nature of adjustments to a conventional Weitzman measure of net national income that would be required: he discusses, for example, the treatment of defensive expenditures and finds that they should not be deducted as is widely canvassed. It is important to be clear that Maler's particular results follow from his model specification in regard to the determinants of environmental quality and the way that it impacts on production and household utility Different model specifications in regard to these matters are plausible, and would be expected to produce different particular results. This is an important lessons to be learned from this kind of exercise - what we think it is necessary to do to adjust current national income accounting practices to measure sustainable income depends crucially on our understanding of the way resources and the environment enter production and impact on household well-being.

The results discussed thus far in this section relate to situations in which valuation uses shadow prices derived from an intertemporal optimization exercise. The question which arises is whether they hold for market prices. Could, that is, Maler's Adjusted Net National Income be measured using actual prices rather than shadow prices? The answer to this question is no.

Consider first the restricted context of Weitzman (1976). If it could be assumed that all markets were fully competitive, that all agents had perfect foresight, and that they all operated with the same consumption discount rate as used in the optimization exercise, then the required investment shadow price would emerge in markets. These are not very plausible assumptions.

Now introduce resource and environmental assets. Given similar assumptions to those above the same result would carry through. However,

the assumptions are even less plausible in the expanded context. Given the absence of private property rights, markets simply do not exist for many environmental assets or the services that they yield. Many, but not all, agents, natural resource assets are effectively owned by individual agents, but few of the markets arising could reasonably be regarded as satisfying the conditions for being fully competitive. Quite apart from questions of foresight, there are very basic problems about relying on market prices to extend the range of assets covered in national accounting to include natural resources and environmental assets. This is widely recognized.

Given a desire to do natural resource accounting for adjusted net national income measurement, two reactions are possible - valuation everywhere by shadow prices emerging from constrained optimization, or valuation by market prices where available plus market-surrogate valuations elsewhere. Each of these approaches involves major difficulties at the level of principle and practice. They differ in the extent to which they are appropriate if the objective is to produce information relevant to sustainable development. It will be convenient to refer to the first as *Social Valuation* and the second as *Extended Market Valuation*. With the two exceptions noted above, all contributions in natural resource accounting to date appear to fall within the extended market valuation category. Indeed, for most contributors to the literature it would appear that the question of an alternative approach has not arisen.

Extended market valuation is attended by many difficulties of principle and practice. All contributors to the literature recognise this to some extent. There is a presumption that the problems are greater with environmental assets and their services, than with resources. This is because markets are more prevalent with the latter than they are with the former. However, even in regard to resources where markets are well established there is disagreement in the literature over whether market prices can be used, and over how they should be adjusted if this is considered necessary: see, for example, Repetto *et al* (1989) and El Serafy in Ahmed *et al* (1989) on valuing nonrenewable resource stocks.

The natural resource accounting literature has devoted relatively little attention to the problems of surrogate market valuation for environmental assets and their services. Attention to matters of this nature has generally been confined to discussion of the treatment of the so-called defensive expenditures. Peskin (Peskin with Litz, 1990, and in Ahmad *et al*, 1989) has considered both defensive expenditures and the wider problem of including environmental assets in the accounts. In the environmental economics literature in recent years a great deal of attention has been given to surrogate market valuation of environmental services to consumption.

The problem is treated within the framework of the revalation of individual willingness to pay for public goods, and in a project appraisal context rather than a national accounting context. Useful reviews are: Mitchell and Carson (1989), Freeman (1985), and Pearce *et al* (1989). A number of methods have been developed, and there is disagreement as to their relative merits, and as to the reliability of the new most favoured approach, which is known as Contingent Valuation as it involves asking people what they as individuals would be willing to pay in a hypothetical market.

For the purposes of natural resource accounting to promote sustainable development, there are problems with the extant approach to environmental asset valuation which arise even if it is judged to be reliable within its own terms. These arise from the fact that those terms involve acceptance of the principle of consumer sovereignty, ie of the premise that the ultimate measure of value is individual willingness to pay. Many who are concerned to promote sustainable development would not accept this premise. Further, revealed individual willingness to pay, which is what methods such as Contingent Valuation seek to measure, is conditioned on individual information as well as on the individual budget constraint and preference system. It can be questioned whether the information available to individuals in relation to the role of various environmental assets in determining their wellbeing is generally such as to warrant elevating their revealed willingness to pay for such assets to the status of measuring sustainable income/social wealth.

Section 6 below considers some extant, unofficial examples of the extended market valuation approach to natural resource accounting.

The social valuation approach would involve deriving the values to be used for constructing adjusted net national income type accounts from a constrained optimization exercise. A major attraction of the social valuation approach is that it would produce an internally consistent set of valuations for constructing accounts. Such valuations could also be used to inform intervention in the market system, by means of taxes for example, to guide development in a sustainable direction. A major problem would the choice of objective function, which given the constraint set, would determine the valuations. Different individuals and groups would want different objective functions. However, while this is a problem if the task is seen as producing a unique set of valuations, it is a benefit if the problem is seen as exploring the dimensions of social choice about development alternatives and the implications arising for valuation. As a practical matter following this approach would present formidable intellectual challenges in regard to the development of a model of the constraint set which was both computationally tractable and capable of yielding valuations useful for

policy purposes. This set would necessarily involve production functions for a number of commodities, each of which would have as arguments flows to and from the natural environment as well as labour and capital inputs, and corresponding thereto a large number of stock-flow relationships of the type shown at B in Table 1 here.

In regard to policy, it should be note that while this type of modelling could in principle generate valuations which would permit of the construction of consistent value stock accounts (balance sheets) or adjusted national income accounts, this would in a sense be a relatively minor output from the exercise. More importantly, the modelling would indicate the consequences of alternative formulations of the objective, or social welfare, function for a given constraining set, or of variations in the constraint set for a given objective function. This second possibility is particularly interesting given that just as the perfect foresight assumption for competitive agents is clearly quite inappropriate in a world of economy-environment interactions, so it is necessarily the case that the true constraint set cannot be known to any modelling agency. An important recent book (Perrings, 1987) ha shown that economy-environment interactions generate true uncertainty about the future consequences of current actions. Some implications of this point will be returned to below. A necessary conditions for modelling for social valuations would be the existence of a data set of the type referred to above as physical stock accounts. It was noted in the Section 4 here that a few countries have moved in the direction of establishing such a data set.

If it is accepted that, as far as its relevance to the sustainability objective is concerned, natural resource accounting which involves valuation must be forward looking, assessments of its usefulness must be based on recognition of uncertainty. To make the point sharply, suppose that there are no pollution problems and no renewable natural resources, and that production involves inputs of non-renewable resources and Kapital only. Then it is intuitive that if non-renewable resources are in a strict sense essential in production there is no positive level of consumption which is indefinitely sustainable, whatever investment/savings program is followed. Generally, it is clear that future prospects depend on the current split between consumption and saving/investment, on the pattern of investment across the various assets, and on the possibilities for substituting forms of Kapital for depleted resources and environmental assets, in production and consumption. On the whole economists tend to believe that we effectively live in a world where these assets need not be regarded as strictly essential, while conservationists tend to believe that they have to be regarded as strictly essential. The use of "believe" here is deliberate. The matters involved are not

amenable to definitive resolution. What is certain is that there is no variety of natural resource accounting that will resolve it, even at the level of principle and leaving aside all the messy details of practical implementation. If natural resource accounting cannot determine whether sustainable development is feasible, it cannot produce results that assure us that what has been happening is consistent with sustainability. If a choice is to be made between the two approaches to valuation sketched here, for example, it should be made in the light of a proper appraisal of what could conceivably be achieved.

6. Examples of the Extended Market Valuation Approach

This section looks at three recent unofficial attempts to construct adjusted net national income type accounts, using the extended market valuation approach. The intention is to consider the extent to which such can usefully inform policy toward sustainable development.

Repetto *et al* (1989) have computed accounts for *Indonesia* which incorporate adjustments for depreciation of the environmental assets oil, timber and soil. They reject the idea that natural resource accounting in physical terms is useful, since it precludes the possibility of aggregation, which is required for the production of single performance indicator. They also, on the same basis, take issue with the emerging consensus among national accounting statisticians, noted above, that valuation in regard to environmental assets should be kept separate from the income accounts in satellite accounts. Repetto *et al* (1989, p. 26) note that such a procedure would 'provide a means of recording changes in the value of net assets between successive measurement dates without having to show any effect on the income of the intervening period' and claim that this means that for the underlying problems the procedure 'is likely to minimize their consideration in national policy analysis'.

For the period 1971 to 1984 Repetto *et al* calculate Net Domestic Product, NDP, by subtracting from GDP allowances in respect of oil depletion, timber depletion, and soil erosion. They proceed by first constructing physical accounts, and then applying valuations. In the case of oil they allow for additions to resources by new discoveries, and for price changes. Oil stocks are valued by subtracting extraction costs from market values for extracted oil. Repetto *et al* note the disagreement in the literature as to how stocks of natural resources should be valued for incorporation into adjusted income accounts. The physical data used by Repetto *et al* are reasonably firm, and if market prices are accepted as appropriate so is the value data. In the case of timber they allow for extractions and natural

growth as in Table 1 here. The physical data here are less firm than in the case of oil. Valuation is on the basis of the difference between harvesting costs and export value, and it is noted that from the point of view of market surrogacy this data is somewhat questionable. In the case of soil erosion, all data are estimates. Physical losses estimated from geographical considerations are valued using estimates of productivity losses.

Table 2 here presents the results in index number form for GDP and NDP, gives the ratio of NDP to GDP, and gives the annual growth rate equivalents of the 1984 index numbers. The NDP growth rate is substantially lower than that for GDP. The NDP series is much more erratic than that for GDP, and the ratio NDP/GDP varies widely. This is principally due to the effect of price changes for, and new discoveries of, oil. This can give rise to problems in the use of NDP figures. For example, 1971 was a year in which the value of known oil stocks actually increased substantially, whereas in 1972 they decreased. If the base for the growth rate calculations is shifted to 1972, the NDP growth rate changes to 5.3%, while the GDP

Table 2: *GDP and NDP for Indonesia 1971-1984*

	GDP	NDP	NDP/GDP
1971	1	1	1.20
1972	1.09	0.90	0.99
1973	1.22	0.97	0.96
1974	1.32	1.48	1.36
1975	1.38	0.98	0.85
1976	1.47	1.12	0.92
1977	1.60	1.08	0.81
1978	1.73	1.19	0.78
1979	1.83	1.19	0.78
1980	2.01	1.28	0.76
1981	2.17	1.48	0.82
1982	2.22	1.58	0.86
1983	2.32	1.49	0.78
1984	2.44	1.68	0.83
	7.1%	4.1% equivalent growth pa 71-84	
	6.9%	5.3% equivalent growth pa 72-84	

NDP = GDP - Oil depletion
- Timber depletion
- Soil depletion

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one changes to 6.9%. This potential for wide year on year variation in NDP type figures, due to new discoveries and/or major price changes, is one of the reasons for a widespread view in favour of keeping asset valuation accounts separate from income accounts. Another way of viewing the problem is to note that the NDP figures for 1973 and 1974 imply that Indonesia's sustainable productive capacity increased by 51% in one year!

A more serious problem from the point of view of the stated objective of Repetto *et al* is that it cannot be assumed that the NDP growth rate represents a sustainable growth rate. This would be true even if they had allowed for all of the environmental assets used in production, rather than just three. As Repetto *et al* are clearly aware, a necessary condition for sustainability is that depleted environmental assets are replaced with Kapital assets - the Hartwick rule. This is not sufficient unless Kapital is substitutable for environmental assets in production, as discussed above. For sustainability, the proceeds arising in environmental asset depletion must be invested not consumed. The fact that NDP has been rising in the past does not assure us that this is, or has been, happening. Nor does any particular value for NDP have any particular significance in this regard.

One needs to look directly at the figure for the value of total net investment to see if it is non-negative. Repetto *et al* do not do this. Clearly, it is necessary for this to have the value of total environmental asset change as an input to the calculation of total net investment. The point is that, given a concern for sustainability, calculating NDP is not the most obvious way to use such information. The most obvious way is to use it directly, to see if the total net investment figure is non-negative. Also, it should be noted that, as Repetto *et al* themselves point out, the standard accounting procedures would need further extensions, to include for example additions to "human capital", before the relevant total net investment figure could be derived.

Young (1990) has prepared some adjusted national income accounts for *Australia*. They are similar to those of Repetto *et al* in that the end product is a time series for NDP, although Young does not actually use this terminology. They differ in several ways. Young treats all mineral resources in the way that Repetto et al treat oil only. Young treats timber extraction solely in terms of its implications for wildlife habitat loss. Young's approach to soil degradation does not involve going through a physical accounting stage, but is based on productivity loss estimates. Like Repetto *et al*, Young ignores other renewable resources. Unlike Repetto *et al* Young does include some accounting for environmental pollution effects, as he subtracts an estimate of expenditures by households and government to offset the adverse effects of waste accumulation. It has already been

noted here that the treatment of defensive expenditures is a matter of some disagreement in the literature: see, for example, Pearce *et al* (1989) and Peskin with Lutz (1990). Whereas Repetto *et al* are concerned with sustainable productive capacity, Young is here apparently introducing some welfare considerations. Young describes his calculations as "back of the envelope", and claims to have been "environmentally generous" in guesstimating.

Table 3 here reports Young's GDP and NDP results in index number form, with the equivalent overall annual growth rates for 1980-88, and the ratio of NDP to GDP. As indicated Young computes two NDP series, where NDP1 corrects only for soil depletion, habitat loss and pollution, and NDP2 also includes mineral depletion. Several points are worth noting. First, NDP1 differs little in its behaviour from GDP (and averages 95.4% of GDP). Second, for NDP2 remarks similar to those made above in relation

Table 3: *Adjusted Income Accounts for Australia 1980-88*

	GDP	NDP1	NDP2	NDP2/GDP	GDP/POP	NDP2/POP
1980	1	1	1	0.84	1	1
1981	1.03	1.03	1.16	0.94	1.01	1.13
1982	1.07	1.07	1.14	0.89	1.03	1.10
1983	1.04	1.03	1.15	0.93	0.98	1.09
1984	1.09	1.09	1.04	0.80	1.00	0.96
1985	1.17	1.17	1.34	0.96	1.06	1.22
1986	1.22	1.22	1.62	1.11	1.08	1.44
1987	1.25	1.26	1.09	0.73	1.09	0.95
1988	1.31	1.32	1.52	0.97	1.12	1.30
	3.4%	3.5%	5.4%		1.4%	3.3%

NDP1 = GDP - Land degradation
- Habitat loss (in forest harvesting)
- household defensive expenditure (pollution)
- government defensive expenditure (pollution)

NDP2 = NDP1 - Mineral depletion
POP = Population

to the NDP results of Repetto *et al* apply. Third, over 80-88 NDP2 growth is considerably higher than GDP growth. Fourth, adjusting for population growth, which Repetto *et al* did not do, has a substantial impact on measured

growth rates, but these remain positive for GDP and both versions of NDP.

The conclusion is (Young, 1990 p. 23) that "environment driven modifications to the national accounting system are unlikely to change the way we manage our economy". Given that it refers to the Extended Market Valuation Approach, this is consistent with the argument developed here on a priori grounds. Young (1990, p. 23) then suggests a list of indicator variables for inclusion in a national welfare function, and states that: "If every element in this vector continued to increase then we might be on a sustainable development path". No related quantitative results are given.

Daly and Cobb (1989) have, however, done calculations for the *USA* which are driven by a very similar motivation: see Section 2 above. They call the end product of their calculations the Index of Sustainable Economic Welfare, ISEW. Dail and Cobb do not regard their ISEW as approximating very closely to what they would want to see as the proper measure of social welfare. Principally, Daly and Cobb reject consumer sovereignty as the only yardstick by which social welfare should be assessed. However, they are constrained by their non-use of an optimizing approach to continue to use market prices, or surrogates thereof, for valuation. Daly and Cobb argue that even imperfect alternatives to conventional accounting measures would lead to improved policies with respect to threats to sustainability. Some comments on this argument appear below.

Given their concern for welfare rather than productive capacity, Daly and Cobb derive their ISEW time series for 1950-86 by a number of adjustments to aggregate personal consumption rather than to GDP. The adjustments are listed in Table 4. The distributional index, D, is a variant on the Gini Coefficient set at 100 for 1951, and decreases if inequality decreases relative to that year. Household labour services, E, is the value of unpaid work in the home. Long term environmental damage, U, is an estimate of future costs attributable to global climate change. The other items are reasonably self-explanatory as to their nature. The calculation of the value of non-renewable resource depletion is quite different from that of Repetto *et al* (1989) and Young (1990). Table 4 indicates that a great deal of effort has gone into the creation of the ISEW, given that for many of the items data were not readily available in publicly available time series but had to be guesstimated from a variety of sources.

Table 5 reports some summary statistics based on the results given in Daly and Cobb, in terms of equivalent annual growth rates for index numbers for 1986 using the indicated base. Daly and Cobb themselves use 1950 and 1951 as alternative bases, because the change in per capita ISEW between those years was greater than at any other time during the period considered. They prefer the base 1951. Summarising their work in this

Table 4: *The calculation of the Index of Sustainable Economic Welfare*

ISEW = ([C/D]
+ [E+F+G+H]
– [I+J+K+L+M+N+O+P+Q+R+S+T+U]
+ [V+W]) / Population

C personal consumption
D distributional inequality index
E household labour (extra-market)
F consumer durables services
G streets and highways services
H consumption of public health and education services
I consumer durables expenditure
J defensive private spending on health and education
K advertising (national)
L commuting cost
M urbanization costs
N auto accident costs
O water pollution costs
P air pollution costs
Q noise pollution costs
R wetlands loss
S farmland loss
T non-renewable resource depletion
U long-term environmental damage
V net Kapital growth
W change in net international indebtedness

Table 5: *GDP and ISEW growth rates for the USA*

	1950-1986	1951-1986
GDP	3.34%	2.55%
GDP/POP	2.02%	1.52%
ISEW	0.87%	1.00%
ISEW1 = ISEW without distributional index adjustment	1.09%	0.76%
ISEW2 = ISEW1-E	3.14%	0.76%
ISEW3 = ISEW1+T	1.13%	0.80%
ISEW4 = ISEW1+L+M+N	1.12%	0.78%

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way means overlooking the different time paths for GDP and ISEW, which Daly and Cobb analyse to discuss aspects of the historical experience of the USA over 1950 to 1986: they particularly note the changing influence of the distributional inequality index. However, in the upper part of the table, their major point is revealed - even when expressed on a per capita basis GDP growth overstates sustainable welfare growth. However, the extent to which this is true is very sensitive to which base year is used.

Leaving this aside, one has to ask "how would a growth addicted policy-maker react to being told that the economy had not been performing as well as previously understood?" in this particular way. It seems plausible that he might well say "OK so we need to stimulate consumption growth some more". Now, of course, this would, according to Daly and Cobb, increase some negative arguments in the ISEW, possibly to the extent of causing the index to show a decline at some future date. But presumably given the model on which this prediction is based, this could have been demonstrated to the policy maker without the need to conduct a real-time experiment. Daly and Cobb's implicit view that policy-makers learn from past outcomes but ignore predictions and argument as to the future consequences of current actions seems to be at odds with their behaviour in other contexts. Further, the understanding of the historical record is itself conditioned by acceptance of some sort of model or view of the way the world works. Subject to some minor caveats, the social welfare function implied by the listing and signs given in Table 4 could be suitable for use with an appropriate constraint set in physical terms to analyse policy choices, and to derive shadow prices. This is quite different from agreeing with Daly and Cobb that an ex post record of values taken by an aggregate over the function arguments, using arbitrary market or surrogate valuations for aggregation, is likely to influence policy in a direction that addresses threats to sustainability. The position of Daly and Cobb really represents a judgement about the way the policy making process works. It may, of course, be a correct judgement about the current situation. However, even if this is the case, it remains true that reliance on their approach with the model not made explicit, will mean policy reaction to past events rather than any capability to anticipate events.

The lower half of Table 5 gives the growth rates figures arising from some illustrative adjustments to ISEW using the data provided by Daly and Cobb for its individual components. It might reasonably be argued that while intratemporal equity is an important problem, it is advisable to keep consideration of it separate from the historical record intended to throw light on sustainability as an intertemporal problem. ISEW1 is light on sustainability as an intertemporal problem. ISEW1 is ISEW calculated without the

adjustment to personal consumption of division by the distributional index. The effect on ISEW is not great, but it is of opposite sign according to the base year chosen. From Table 4 E is the value of unpaid household labour services, which enter Daly and Cobb's implied social welfare function positively. It is not obvious why an increase in unpaid domestic labour should, other things equal, be regarded as welfare increasing. Leisure does not appear in Table 4's listing. ISEW2 modifies ISEW1 by leaving out the imputation for unpaid domestic labour. The effect is fairly dramatic. The differences between ISEW2 growth rates and ISEW1 growth rates exceed those between the growth rates for per capita GDP and ISEW. If nothing else, assessment of an ISEW is very sensitive to this item where inclusion and measurement are contentious. T is the non-renewable resource depletion allowance, on which there is some consensus for inclusion in some way, and which is widely regarded as one of the major threats to sustainability. ISEW3 adds this allowance back in so ignoring non-renewable resource depletion. The growth rate differences ISEW3-ISEW1 are very small, and much smaller than those for ISEW2-ISEW1. Do we really want to believe that unpaid domestic labour is more significant for sustainable welfare than non-renewable resource depletion? In Table 4 L, M, and N are respectively commuting costs, urbanization costs, and auto accident costs. While urban life and road traffic deaths may be and obviously are respectively important problems, it is not clear that they as such represent major threats to sustainability. The resource depletion and pollution associated with urbanization may well represent major threats, of course, but as Table 4 indicates these are already accounted for elsewhere in the ISEW. In fact as Table 5 shows at ISEW4, in terms of growth rates the impact on the Daly and Cobb index of sustainable economic welfare of urban life and road traffic deaths themselves is very close to the impact of non-renewable resource depletion.

The point here is not to denigrate the efforts of Daly and Cobb. It is that their efforts reveal the problems of an ad hoc approach to the problem via the Extended Market Valuation approach. The results reported in the lower part of Table 5 are but a few of the games that it is possible to play with the data that they provide in the Appendix. It appears that such games could all too easily be used to impede real progress in the evolution of policies to address threats to sustainability.

7. Accounting for Ecological Sustainability

The notion of sustainability, or sustainable development, is not unambiguous. There is no disagreement, for example, over whether the term needs to be qualified by the use of "ecological". Some take the view

that the ecological dimension is subsumed by the term itself so that the qualifier is redundant. While this is in part a matter of semantics, it has to be recognized that there are different approaches to the analysis of sustainability issues. This is discussed in Common and Perrings (1991), where an economic approach is distinguished from an ecological approach. The former is characterised as being driven by seeing the problem as managing the biophysical system for strictly human purposes, where those purposes are interpreted in individualistic terms. The latter is characterised as being driven by seeing the problem as managing the biophysical system so as to maintain the viability of that system. The approaches also differ in their treatments of the relationship between human activity and the biophysical system. Common and Perrings suggest the basis for an "ecological economics" approach to sustainability, which would retain a concern for human purposes but subject it to constraints intended to protect system viability.

Previous sections of this paper have largely, but not entirely, reflected the influence of what Common and Perrings characterise as the economic approach. This is because it is that approach which has dominated work on natural resource/environmental accounting to date. There has been some work on data requirements for ecological sustainability, which can best be referenced with the "environmental indicators" label used in Section 3 above. This work has not always been linked to sustainability considerations of any kind, at least explicitly. Most of the consideration of data requirements following the Brundtland popularisation of the sustainability idea appears to have been concerned with the economic approach to the matter.

An ecological approach to sustainability can be taken to be based on the work of Holling (Holling, 1986, for example) on the stability and resilience of ecosystems. Following Holling, stability refers to the propensity of the populations in an ecosystem to return to equilibrium states following perturbation, whereas resilience refers to the propensity of the ecosystem to retain its organisational structure following perturbation. Common and Perrings define ecological sustainability as resilience of the global system, and propose an ecological economics formulation of the sustainability problem in terms of an optimization problem where ecological sustainability conditions are incorporated into the constraint set.

Given this approach, the problem of monitoring whether or not the sustainability constraints are being satisfied arises. Prior to the problem of providing the data for such monitoring is the problem of identifying the appropriate indicators. While there might be some consensus on the general nature of resilience indicators - changes in species diversity, changes in

standing biomass, changes in trophic structure, changes in mineral micro nutrient stocks etc - current understanding does not appear to be such as to reduce this to a specific and manageable list of indicators. However, it is clear that the data requirements arising from a concern with ecological sustainability would be different in character from those addressed in the natural resource. environmental accounting literature. In that literature, as discussed above, the main thrust is the search for a single indicator, Adjusted Net National Income, which would necessarily be expressed in value terms. Ecological sustainability indicators would necessarily be expressed in physical terms. The two types of data are not, of course, mutually exclusive.

While this important difference exists, there is a feature common to both approaches. In both areas data collection and reporting needs to be informed by improved understanding based on analytical and empirical research. This itself implies the need for data of course. The point is not that efforts to improve the availability should be informed by, and develop in conjunction with, ongoing research into the problems of concern.

Monitoring for ecological sustainability involves data generated by state of the environment reporting activity, i.e. environmental indicators. In this area, the role of theory and related empirical research appears to be less than the natural resource/environmental accounting context. While the work in the latter area builds on experience with national income accounting which is itself informed by economic theory and the needs of economic management, ecological theory appears to have had little impact in the environmental indicators area and "ecological management" appears to be an empty set at present.

It can also be noted that the social valuation approach to natural resource accounting, discussed above, would not be inconsistent with incorporating ecological sustainability constraints into the formulation of the overall problem. There is no good reason to suppose that extended market valuation will reflect sustainability constraints. Precisely the advantage of the social over the extended market approach is its ability to improve understanding of the overall problem and to relate that understanding to policy questions. It could be that one of the impediments to progress in the environmental indicators areas is that it is typically not very clear how such data relate the problems perceived by policy makers or to the levers of policy.

8. Conclusion

The major conclusion is that the extended market valuation approach to

natural resource/environmental accounting has little to offer in terms of promoting sustainable development. It could be counterproductive. Extended market valuation is attended by many practical difficulties, and the reliability of extant methodologies for surrogate market valuation of goods which do not pass through markets remains in doubt. More fundamentally, the approach rests on the assumption that prices corrected for market failure, i.e. prices reflecting what individual willingness to pay would be like if everything of concern was traded in competitive markets, are the prices which would support sustainable development. Given many interpretations of what sustainable development would involve, and the information available to individuals, this is not a plausible assumption.

It is not clear that any single number ex post performance indicator would of itself usefully inform progress toward sustainable development. Such a number would necessarily be in the nature of a valuation. Such a number could be produced as part of the output of an exercise in constrained optimization, which exercise has been referred to here as the social valuation approach to natural resource accounting. The production of this type of backward looking performance indicator would, however, be a rather unimportant part of the exercise. The important part would be the use of the modelling involved to improve understanding of the issues and trade-offs involved in the pursuit of sustainable development, and to inform policy consideration.

The modelling exercise would require inputs of physical data, both of the type usually considered in the natural resource/environmental accounting area and of the type usually considered in the environmental indicators area. It would offer the prospect for bringing together the economic and the ecological approaches to the question of sustainable development. The extended market valuation approach to natural resource accounting does not offer this prospect. Modelling for improved understanding would inform data collection and generation work.

The implied priority here in favour of physical data work over work to modify national income accounting procedures is consistent with the position currently taken by the ABS. The ABS is starting work relating to environmental indicators. The ABS is not the only agency in Australia interested in and/or active in these areas. In the absence of co-ordination the potential exists for duplication and waste of effort. Given the magnitude of the task realisation of this potential should be avoided. Simultaneous and co-ordinated work in modelling and data supply would help in avoiding this potential waste of effort.

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