Natural Resource Accounting (I): A Review of Existing Frameworks

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Natural resource accounting has emerged from the need to better understand the relationship between human, social and economic systems and those of the natural patrimony.[1] This relationship consists of the provision of various environmental services to human populations, in the form of: 1. consumptive, usually market resources (biological and non-renewable) for economic production; 2. assimilative services which are commonly subject to incomplete or non-existent markets; and 3. environmental quality resources, some of which are essential to human health but few of which are characterised by clearly delineated property rights and markets.

Natural resource accounting frameworks have emphasised two goals in building structures for the provision of information on the use of the natural patrimony. The first of these is to correct the perceived shortcomings in the 1968 and still current version of the United Nations framework System of National Accounts (SNA) vis-à-vis the derivation of income from non-sustainable consumption of natural resources and other environmental services. The second major goal involves the provision of information per se, rather

1. Patrimony is described by Weber (1983: 426) as "...everything that has been bequeathed to us by our forebears and which we have brought to fruition or squandered. In other words, it is everything that we can transmit to future generations." Natural patrimony is the natural system component of this bequest. This includes all ecosystems and ecosystem constituents that are significantly influenced by humans due to social and economic activity; that is, influenced on a scale comparable with naturally occurring fluctuations.

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than as a component of expanded macro-economic accounting.[2]

Since the release of the SNA in 1968, considerable attention has been directed toward evaluating macro-economic indicators, particularly GDP and GNP. The core of the debate has centred on the adequacy of these measures as indicators of economic well-being.[3] A number of problems have been identified and significant effort has been focused on developing revisions to the SNA. One of the principle shortcomings relates to the failure of aggregate indicators to reflect the contribution of environmental inputs to economic output and a concurrent failure to reflect the implications for future well-being of environmental deterioration due to economic activity (Scott 1956; Peskin and Peskin 1978; Landefeld and Hines 1985; Hueting 1989; Repetto et al. 1989; Dasgupta 1990; Hueting and Bosch 1990; Bartelmus et al. 1991; Dasgupta and Mähler 1991). According to Hicks (1946), income should be a measure of the capacity of an individual or group to consume without reducing future capacity to consume *ad infinitum*. Recently, this idea has been focal in the development of a concept of sustainable income (Daly 1989) and was adopted at the United Nations Environment Program (UNEP)/World Bank expert meeting on environmental accounting and the SNA (Friend 1989). The implications of the Hicksian income concept where economic accounting for the environment is concerned are considerable; the net revenue generated from any economic activity which uses environmental inputs or services and which simultaneously causes a reduction in the future capacity of natural systems to supply these services contains a capital component equal to the value of the reduced environmental capacity. This natural capital consumption must be netted out of traditional income concepts to arrive at Hicksian income. Most recent efforts to revise the treatment of natural resource depletion and environmental degradation in the macro-economic accounts has been devoted to a satellite accounting approach in which the generation of income and the consumption of capital where natural assets are concerned are to be explicitly distinguished.

The other major rationale behind the construction of resource accounting frameworks is the provision of information on human use of the natural environment. Gilbert and Hafkamp (1986) specify that the major shortcoming of

2. Peskin and Lutz (1990) devised a system for classifying resource accounting systems based upon four categories: identification of defensive expenditures; physical resource accounts for stocks and flows; macro-economic aggregate adjustment; and comprehensive monetary and physical accounting. However this classification system has not been adopted herein largely because these four are subsumed by the two generic objectives listed. Also, it seems as though Peskin and Lutz have employed the integrated category for systems which are heavily dependent on monetary accounting, including the system designed by Peskin himself (Peskin, 1989a and 1989b; Peskin and Peskin, 1978).

3. Much of the debate over the SNA has to do with the conflicting goals of the system, namely to reflect both welfare and economic output (Dreschler, 1976). As long as welfare and economic output are not mutually inclusive, the macro-economic accounting system will fail to completely satisfy proponents of both total output and welfare accounting.

exclusively SNA-based planning and use of the resource and environmental information contained in resource accounts is that it emphasises a single social objective, that is, economic growth, to the exclusion of other goals. These may include, for example, sustainable development objectives such as the maintenance of a certain standard of environmental quality. In general, the development of sound environmental planning and the use of models for characterising the relationships between societies, economies and environments are both hindered by a paucity of environmental statistical frameworks that provide empirical links -- qualitative as well as quantitative -- between environmental and social systems (for example, Beanlands and Duinker 1983). This information can be useful in a number of different capacities, making resource accounting frameworks which emphasize the provision of such data more closely related to state of the environment reporting, economic-ecological modelling, input-output analysis[4] and environmental statistical systems such as Canada's Stress Response Statistical System [STRESS] and the United Nations' Framework for the Development of Environmental Statistics [FDES] (Rapport and Friend 1979 and UNSO 1984 respectively).[5] Resource accounting frameworks which stress this multi-objective approach to the use of data on the natural patrimony tend to be founded upon a core of resource accounts in which data are maintained in physical rather than monetary units.

Resource accounting frameworks are designed to monitor human use of the natural patrimony. Generally, this involves an examination of three major functions of the natural environment with respect to human populations:

1. the provision of consumptive, largely market natural resources as inputs to economic production;
2. the assimilation of waste material; and
3. the provision of non-consumptive, largely non-market environmental quality resources, for example, recreation sites (Bartelmus 1990 and Pearce and Turner 1990).

Resource accounting frameworks typically record the stocks and flows of resources, and rates of harvest. For biological resources, extraction that exceeds the natural replacement rate is classified as depletion. In accounting structures that focus on the integration of resource accounts with the SNA, the value of this depletion can be estimated by a number of methods and corrections to the income accounts undertaken (for example, Peskin 1989b). For non-renewable resources, all harvest constitutes depletion (although economic reserves can increase through additions and price adjustments). Again, it is

4. For a review of input-output analysis and its application to ecological-economic modelling, see Lonergan and Cocklin (1985).

5. Friend and Rapport, 1991.

possible to value this depletion and use the result in attempting to adjust macro-economic aggregates.

Non-consumptive resources and the assimilative capacity of the environment have generally received less attention in resource accounting frameworks, largely because most systems have emphasised the adjustment of income accounts; since environmental quality and assimilation services are not typically characterised by clearly defined markets, this makes their treatment in monetary accounting more difficult. In addition, sustainability in the utilisation of these environmental services typically depends on threshold levels in the natural system as well as on policy targets for environmental quality. While such considerations tend to make the treatment of these services difficult in resource accounting, Hueting (1980, 1989) recommends that degraded environmental quality which results from anthropogenic pollution should form a component of resource accounts and should be valued at the best available estimate of restoration costs using sustainable development objectives for environmental quality as targets. The Norwegian resource accounting system is an example of a framework in which stocks and flows of resources were compiled in purely physical terms and in which environmental quality and assimilation services formed core components of the system (Garnasjordet 1983; Garnasjordet and Longvs 1980).

The following sections review the key resource accounting frameworks, ranging from country-specific models to those advocated by specific researchers. These models set the framework for the regional accounting model that is developed in the subsequent article.

Canada

The development of Canadian macro-information systems was initiated in the late 1970s (Rapport and Friend 1979) in order to coordinate the collection, storage and manipulation of disparate types of environmental statistics. The framework was dubbed STRESS, so-named because the structure of the system is based upon the process of anthropogenic environmental stress and response and the implications of this process for human populations. The ultimate goal of the program was, and is, to establish quantitative links between environmental systems and economic systems; little mention is made of non-economic social relationships. From this base, three distinct general database programs have evolved under Statistics Canada (Friend 1984):

1. stocks and flows of natural resources and their connections with the economy;
2. state of the environment databases; and
3. natural productivity databases.

Presently, there are two main natural resource accounting programs operating at the national level in Canada. The first of these is based on work by Friend and Rapport (1991), who have discussed natural resource accounts in a context of moving from income accounts (the SNA) to wealth accounts, a set of biological, non-renewable and cycling systems resource accounts. While one of the goals of the program is to link the natural resource accounts to the SNA, the primary purpose of the program is to provide a "...formal framework for the organization of statistical data on the stocks, flows and status of natural resources" (Friend 1986: 33). Also, there is a strong conceptual link between the foreseen natural resource accounts and the ongoing State of Environment program of Statistics Canada (Friend and Rapport 1991).

The Environment and Natural Resources Division at Statistics Canada has begun to implement a separate framework for natural resource accounting which is much more limited than the previous one and is intended more as a supplement to the SNA, pursuant to dominant trends at the international level. According to Hamilton (1989: 2) "only those resources which have been discovered and which may be exploited at current market prices and with available technology can be considered resources for the purposes of national accounting". That is, only the economic reserves of commercial resources should form the core of the resource accounting system, at least in so far as the connection between the resource and economic accounts are concerned. The main goals of the system are twofold: 1. to produce satellite accounts for natural resources and 2. to value these natural assets for inclusion in the national balance sheets of the SNA (Statistics Canada 1990).

Figure 1 depicts the tentative structure of the Statistics Canada system of resource accounting. Beginning at the base with a broad spectrum of existing data on natural resources (including non-market resources), the first step is to aggregate this information into a series of physically-based resource accounts. This set of accounts is narrowed from the original data in the sense that only exhaustible resources (that is, minerals and petroleum) along with commercially traded biological resources are included. Each resource is assigned a rent value based upon market and technological information. Finally, the stock and extraction rates in combination with the rent estimates yield measures of depletion and natural asset value (Hamilton 1989: 6). A preliminary rough estimate of the value of mineral and petroleum depletion from 1984-1986 totals 41.7 billion (nominal) dollars, comprising roughly 2.9 per cent of nominal GDP over this period.

There are marked differences between the developing focus on a biophysically based system of resource accounting at the Institute for Research on Environment and Economy (IREE) and the official Statistics Canada natural resource accounting system, the latter being more derivative of the SNA and conforming largely with the growing consensus at the UN in favour of satellite accounts (for example, Lutz and El Serafy 1989). The comparative advantages and disadvantages of each approach serve as a microcosm of the debate in

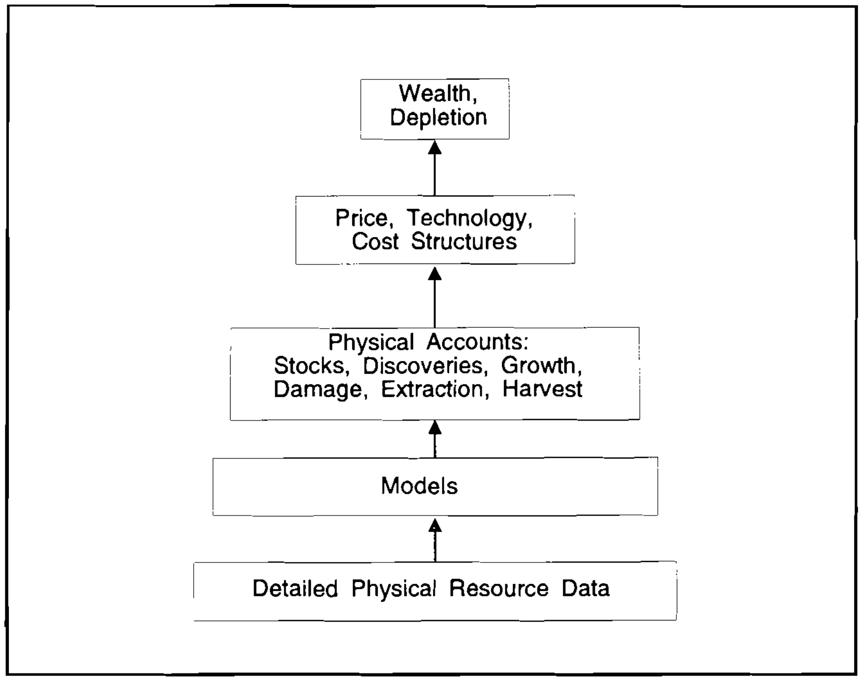

FIGURE 1 Statistics Canada Resource Accounting System

resource accounting in general, with more comprehensive and biophysical approaches seeming conceptually superior from an ecological perspective but also proving very difficult to implement. Also, from a macro-economic accounting perspective, more complex and inclusive systems introduce the possibility of greater uncertainties in the SNA.

Norway

The Norwegian System of Resource Accounts (SRA) is among the earliest examples of a resource accounting structure put together at the behest of a national government in order to systematically record information on the stocks and flows of domestic resources. According to Garnasjordet (1983: 445), the two central purposes of the SRA were:

1. to develop regular reviews of the volume, quality and use of natural resources in the form of 'resource accounts'; and
2. to co-ordinate and present proposals regarding the future use of such resources in the form of 'resource budgets'.

The inclusion of a resource budgeting provision in the design of the system is distinctive to the Norwegian SRA, especially given that the budgets were maintained entirely in physical units of measure. The exclusion of monetary resource accounting grew from a Norwegian perception that monetary accounting either necessitated the exclusion of vital resources from the framework or the implementation of unreliable valuation methodology (Aaheim and Nyborg 1991).

The Norwegian SRA was structured around four physical and two managerial categories of resources. Physical categories included: 1. mineral resources, 2. biological resources, 3. inflowing resources, that is, ambient renewable phenomena necessary for life processes, and 4. status resources that is, environmental media (for example, air and water) with longer term cycling processes. The managerial classification grouped the first three of the above physical classes into the material resources division, while status resources were managed as environmental resources, reflecting the fact that accounting for these necessitates an emphasis on quality rather than quantity (Garnasjordet 1983 and Garnasjordet and Longvs 1980). In compiling the accounts, only physical units of measure were employed and the focus of the SRA was restricted to anthropogenic use of natural environment, that is, the resource base. Also, the classification of economic sectors in the SRA was patterned after the SNA to facilitate more integrated macro-level planning (Aaheim and Nyborg 1991).

The efficacy of the Norwegian system is open to dispute. On the one hand, convincing testimony to the shortcomings of the framework is provided by the simple fact that the system has been largely dismantled. Aaheim and Nyborg (1991) attribute this in large part to the failure of the designers to tailor the SRA to the needs of its users; that is, in some instances data were not collected and compiled in a manner useful for planning and policy, resulting largely in the neglect of certain portions of the database. Also, exclusive adherence to physical units of measure has been criticised for ignoring the unquestionable power of monetary accounts.[6] At the same time, it is difficult to imagine a set of physically-based accounts compiled on a priority basis -- focusing first on forestry and fisheries in BC for example -- being ignored. While it is true that a lack of a reliable aggregation algorithm limits the universality of the model, it is far from apparent that monetary accounts provide this algorithm owing to the pervasive methodological shortcomings of valuation (Pearce et al. 1989; Peskin and Lutz 1990).

6. Peskin (1989a and 1989b), for example, is a staunch supporter of monetary accounting.

Individual Case Studies

Although the majority of research in the area of resource accounting has stemmed from the efforts of various national governments or from the UN, some independent work has been carried out. Three independent resource accounting structures are reviewed here along with selections from the empirical results. These include the work of Repetto et al. (1989), Gilbert (1990), Gilbert and Hafkamp, (1986) and Foy (1991).

The Indonesian Accounts

Repetto et al. (1989) addressed the question of how some measure of natural resource depletion might influence estimates of national income for Indonesia. The method involved compiling accounts of stocks and flows of resources over time, with specific accounts constructed for timber, petroleum and soil resources. Within each account, a measure of the stock at the beginning of the accounting period was listed together with the unit price and an estimate of the total value of the resource. Transactions involving additions or removals from reserves were recorded together with changes in the unit cost over the accounting period. At the end of this period, final stock was recorded, as well as closing unit price and final total value. An example of a generic (non-renewable) resource account is presented in Table 1.

From the table, one can see that the opening stock was 100 units valued at $1 per unit for a total resource asset of $100. The closing stock was reduced to 85 units, but because the unit price rose to $3, the total value of the asset at the end of the accounting period increased to $255. The adjustment recommended by the authors is to treat the increased value as unrealised income in an auxiliary account to the SNA. However, the quantity depleted has been used to generate gross income, roughly on the order of the amount removed valued at the average (net) unit price over the period. Repetto et al. (1989) recommend that Net Domestic Product (NDP) adjustments from exploitation of the resource should amount to precisely this figure; that is, if the 15 units removed are valued at the average unit price of $1.60, then the gap between GDP and NDP should widen by $24. For forest resources, depletion was defined as any amount of anthropogenic reduction in timber stock. While the structure of the account presented in Table 1 is clear, it is notable that the adjustment recommended by the authors assumes that the exploitation of resources in a non-renewable fashion can generate no real income, an assumption that El Serafy (1989) argues against. Also, the authors made no attempt at estimating total economic value for the resources in question. While attempting to do so would have added to the complexity of the project, the magnitude of these values could be significant in the cases of soil and forest resources.

Repetto et al. (1989) assessed the aggregate magnitude of their adjustments

TABLE 1 Example of an Indonesian Resource Account

	Physical Units	Unit Value	Value
Opening Stock	100	1.00	100
Additions			
Discoveries	20	1.60	32
Revisions	(30)	1.60	(48)
Extensions	15	1.60	24
Growth	0	1.60	0
Reproduction	0	1.60	0
Reductions			
Production	(20)	1.60	(32)
Deforestation	0	1.60	0
Degradation	0	1.60	0
Net Change	(15)	1.60	(32)
Revaluations			
Opening Stock	--	--	--
Transactions	--	--	--
Closing Stock	85	3.00	255

Source: Repetto et al. (1989).

for the Indonesian economy from 1971 to 1984. According to these estimates, while the average annual rate of growth of reported Indonesian GDP was seven per cent over this period, applying corrections for resource depletion reduces this figure to four per cent. The authors argue that this reflects the dependence of the Indonesian economy on the natural resource base over this thirteen year interval and that some measure on the order of their corrections is appropriate in moving toward macro-economic indicators of sustainable development. The implications of this result for other developing nations are severe given the tendency of developing nation economies to be heavily dependent upon the natural resource base.

Gilbert's Framework and Case Study

Gilbert (1990: 307) has described natural resource accounting as "...a methodology for presenting environmental, resource and economic information." This reflects her contention that exclusively SNA-based planning and use of resource accounting structures results in an overemphasis on strictly economic goals. Other important objectives (Gilbert and Hafkamp 1986) include: 1. sustainability in resource quantity and quality, 2. sustainability in resource use by society (vis-à-vis equity for example) and 3. sustainability of environmental service production (for example, recreation opportunities and other non-consumptive uses). Pursuant to this multi-objective approach, Gilbert (1990; Gilbert and Hafkamp 1986) has designed a resource accounting framework which is designed to supplement the SNA as well as to provide information on the socio-economic environmental interface. This framework consists of three components: 1. resource user accounts, 2. ecological or stock accounts, and 3. socio-economic accounts.

The resource user accounts describe the input of natural resources and environmental services to various economic sectors and the output of materials from these sectors to the natural environment; thus the structure is reminiscent of an input-output approach. Specifically, user divisions are listed as fisheries, livestock, crops, forestry, conservation, recreation, water storage, urban and transport and waste disposal (mining is also mentioned, Gilbert 1990). Inputs include stocks of resources, effort, infrastructure, investment and government policy with outputs entailing yield, income, value added and environmental impact. Gilbert (1990) also specifies that monetary and physical units are to be employed in the user accounts.

The ecological or stock accounts are classified by abiotic categories such as air, land, water and subsoil resources and by biotic categories entailing ecosystems and ecosystem components. These accounts use only physical measures. The generic accounting identity for resource stock accounts is derived from the relationship between initial stock, growth (and other recruitment) and imports on one hand and consumption, exports, natural losses and final stock on the other. This is not unlike similar identities for physical accounting found in other models (for example, see Repetto et al. 1989 and Theys 1989).

The socio-economic accounts consist of three separate sub-components: the economic, demographic and policy sub-accounts. The first of these is derived from the SNA with re-classification of certain sectors for the sake of congruency with the rest of the accounting framework. This sub-component, according to Gilbert (1990), is structurally similar to a transaction matrix from a standard input-output table. The demographic sub-component describes facets of societal interaction with the environment, for example, regional population growth or information on direct relationships between local populations and natural resources. The policy sub-component of the socio-economic accounts provide a provision for the description of existing government environmental policy (Gilbert 1990).

Implementation of the Gilbert framework has been attempted in a case study of the application of resource accounting methodology to Botswana (see Gilbert 1990). The potential results from a case study of this nature are attractive indeed given the special significance of resource accounting to developing nations, many of which feature populations with direct dependence on the environment for subsistence (Peskin 1989a; Theys 1989). While the case study of Botswana completed by Gilbert does largely exhibit her methodological intentions, the use of what she calls "dummy numbers" in certain places detracts from the usefulness of the results. More comprehensive implementation would be welcome in this case given the logical coherence and broad scope of the accounting framework. Failing a holistic application of the framework, it would also be useful to highlight the treatment of a single resource in the system, as has tended to be the strategy in implementing the French patrimony system.

Foy's Study of Petroleum Depletion in Louisiana's Gross State Product

Foy (1991) has completed a study of the value of petroleum resource depletion as a component of Louisiana's Gross State Product (GSP) over the period from 1963-1987. Foy attempts to compare quantitatively the effects of applying the total rent reduction method advocated by, *inter alia*, Repetto et al. (1989) and the sustainable income or user-cost method forwarded by El Serafy (1989). This comparison makes the Foy study central to the review of resource accounting methodology.

The overall result of the adjustments in the study is to reduce NSP (Net State Product) by an average of 3.3 per cent using the total rent deduction method and to reduce GSP by 13.8 per cent and 8.7 per cent using El Serafy's method with five and ten per cent discount rates respectively. This result is counter-intuitive given that El Serafy's deduction should be lower. Foy (1991: 37) argues that this is the result of two factors. First, the total rent reduction method may result in an increase in NSP as a result of the valuation of additions to economic reserves. This is not the case in El Serafy's method. Second, Foy argues that while the total rent reduction method involves the calculation of resource rent over the lifecycle of the resource, as per the method recommended by Landefeld and Hines (1985), the user-cost approach involves only the calculation of net receipts in the current year, that is, total receipts minus factor inputs (including an allowance for capital consumption).

The resolution of the debate between user-cost advocates and total rent deduction advocates is beyond the scope of this paper. One should keep in mind, however, the principles inherent in each method; Foy's case study highlights the potential for divergence.

Macro-Economic Accounting

One of the primary emphases behind research in environmental and natural resource accounting involves the search for economic indicators of sustainable development and for a way to integrate these indicators into the existing framework for macro-economic accounting widely accepted internationally, the SNA (Gilbert 1990). The advent of environmental economics has helped to generate momentum in this direction as economists realize the need for corrections to the Keynesian perspective on income at the national level (see *inter alia*, Daly 1989; Harrison 1989; Repetto et al. 1989). Considerable variation persists as to the appropriate degree to which environmental and natural resource accounts should be integrated in the SNA (for example, see Drechsler 1976 and Peskin and Peskin 1978). Two perspectives on this debate are reviewed here: 1. the fully internalised approach recommended by Butterfield (1990) and 2. the satellite system originally formulated by Bartelmus et al. (1991), and expanded in the form of the draft system of integrated satellite accounting released by the UNSO (1990). This is by no means an exhaustive list, but instead is meant to represent a sample of different perspectives on the integration of resource accounting and the correction of accounting aggregates vis-à-vis the SNA.

Satellite Accounting and the SNA

The new draft Handbook on Integrated Economic and Environmental Accounting (UNSO 1990) is a broad-based system intended to supplement the existing SNA with information on the interface between the natural environment and the economy. This vast system contains provisions for physical and monetary accounting (although the latter is emphasized), with direct structural linkage to the SNA. Coverage includes depletion and degradation of natural and so-called environmental resources, with valuation of degradation effects through direct estimates (Hueting 1989) as well as by way of defensive expenditure estimates. The system itself is largely derivative of an earlier version devised by Bartelmus et al. (1991). Although a comprehensive review is beyond the scope of this paper, highlights relevant to this discussion are based on information gleaned from Bartelmus (1989, 1990), Bartelmus et al. (1991) and the draft handbook (UNSO 1990).

Bartelmus (1990: 17) points out that "Accountability of socio-economic policies for their environmental impacts is at the heart of sustainable development. Accounting for both socio-economic performance and its environmental effects is therefore the first step towards the effective integration of environmental concerns into economic policies." He goes on to establish that while physical accounting is critical to the maintenance of sound information bases, some degree of integration with monetary accounting is necessary in deference to the significance of monetary indicators in a planning and policy context. Bartelmus et al. (1991) thus specify the major objectives of the System for Integrated Economic and Environmental Accounting (SEEA) as follows:

1. compilation of a set of physical accounts with linkage to monetary accounts and balance sheets;

2. separation of traditionally aggregated stocks and flows to identify certain environmental relationships, primarily expenditures on abatement as well as defensive or mitigative measures;
3. completion of monetary accounts for both depletion and degradation due to anthropogenic causes;
4. extension of the concept of capital to include natural assets (Scott 1956); and
5. adjustment of accounting identities.

The physical accounts of the SNA are a hybrid of existing natural resource accounting frameworks and the Materials Energy Balance System (MEBS, Ayres and Kneese 1969 and United Nations 1976). There are three main types of physical accounts, all of which have structures which mimic their SNA analogues. These are:

1. the physical flow accounts for products and non-produced natural assets;
2. the physical flow accounts for residuals; and
3. the non-financial assets accounts (UNSO 1990).

The first of these involves the expansion of supply and use tables in the SNA to include both economically and naturally produced natural resources. The physical flow accounts for residuals describe the origins and destinations of largely unwanted by-products from economic production, again in a supply and use table format. This includes inter-industry flow, that is, recycling as well as direct deposition of waste material in natural regimes (UNSO 1990). Non-financial assets accounts are expanded SNA asset accounts for natural assets (as identified in the SEEA classification system), which include biological assets, land and soil assets, fossil and mineral assets (reserves), water and air (UNSO 1990: 105).

The monetary accounting structures of the SEEA are designed to supplement the standard accounts of the SNA with estimates of the economic value of resource depletion and environmental degradation. This is to be accomplished through the expansion of use/value-added tables describing domestic production, value added, final and intermediate consumption of goods and services as well showing the values of opening and closing stocks of naturally and economically produced assets through extensions of the asset or balance sheets. The expansion of the asset sheets is proposed in such a manner that discoveries of new economic reserves are treated as "transfers of wealth" from the environment to the economy, without affecting the macro-accounting identities (Bartelmus et al. 1991): thus the free gift of nature.

Table 2 provides a consolidation of the revised use/value added accounting structure, highlighting some of the proposed amendments. Entries have been added for the consumption of fixed non-produced or natural assets, that is,

TABLE 2 Consolidated Use Value Added Account in the SEEA

	Use Value Added	
	Total	Subtotal (domestic production)
1) Use of products	591.9	224.0
2) Gross value added		293.4 (GDP)
3) Use of produced fixed assets	0	26.3
4) Net value added		267.1 (NDP)
5) Use of natural assets	59.8	59.8
6) Total use	590.3	310.1
7) Environmental adjustment of final demand		22.2
8) Environmentally adjusted net value added		185.1 (EDP)
9) Total gross inputs		517.4

Source: adapted from Bartelmus et al. (1991).

natural resource depletion and the degradation of the environment by waste product deposition, as well as an environmental adjustment to final demand. This latter is the imputed value of depletion and degradation resulting from final demand by households and from the use of human made capital assets (Bartelmus et al. 1991: 127). The value of these environmental inputs and effects is taken to be their replacement value, based on the market price for applicable resources and, for degradation, a technological assessment of restoration of environmental quality to previous or policy targeted levels, as recommended by Hueting (1980, 1989) and Hueting and Bosch (1990). For non-market resources, various means of assessment exist, however Bartelmus et al. (1991) specify that valuation should only be attempted for those resources which are depleted as a result of direct market activities. It would be theoretically possible to implement either the total rent reduction method or the user cost method (El Serafy 1989) in estimating the value of resource depletion, depending upon whether policy-makers wish to enforce a so-called "strong" or "weak" sustainability concept (Bartelmus et al. 1991; Bartelmus 1990).

The recommended revisions of the macro-accounting aggregates under the SEEA are apparent from Table 2. Net Domestic Product (NDP) is calculated as gross value added or GDP less a capital consumption allowance (row 3). Eco-Domestic Product (EDP) is NDP less the eco-margin, the sum of imputed environmental depletion and degradation due to both final demand and the use of human made capital (row 7) plus the value of natural assets as a component of industrial output (row 5). Bartelmus (1990) also outlines the procedure for calculating what he has called environmentally adjusted GDP and sustainable GDP.

The former is derived from traditional GDP less expenditures for environmental protection, the argument being that these expenditures are more a by-product of final demand than a direct demand per se. Sustainable GDP is environmentally adjusted GDP less environmental costs or the value of depletion and degradation due to economic activities. Here the argument is that natural resources are not analogous to fixed capital in as much as they are not produced by human hands.

The very scope of the SEEA is impressive, certainly an improvement upon the SNA in so far as there has been an explicit attempt by the system designers to devise an environmentally inclusive national accounting structure. Nevertheless, the fact that the SEEA has been labelled "integrated" is somewhat misleading. On the one hand, there is no doubt that monetary natural resource accounts are integrated with structures borrowed from the SNA. However, referring back to the major emphases of resource accounting, the apparent overriding concern that emerges from the SEEA is the supplementation of the SNA. This is despite the ambitious claims of the authors to have devised a system of accounting which balances the ecological and economic imperatives, and despite the existence of extensive provisions for strictly physical accounting. While there is nothing inherently wrong with trying to supplement the SNA (in fact, it needs it), it would be somewhat misleading to represent the SEEA as a truly integrated system, ironically because the physical and monetary accounting systems are not sufficiently decoupled to lend credibility to the physical accounts.

Butterfield's Resource Accounting Proposals

Butterfield (1990) has recommended several steps toward the full integration of the value of environmental exploitation into the SNA. Under his framework, resource depletion is seen more as a transfer of "wealth" from a foreign source, in this case the environment. He recommends that, rather than adjusting asset balances for discoveries and NDP for depletion, as in the case of the SEEA, a proper treatment would entail deduction of the value of depletion from GDP. Butterfield draws parallels in this treatment of depletion with that of non-competitive imports in the accounts.

Table 3 provides an example of Butterfield's recommended treatment of resource depletion using hypothetical data for the exploitation of a mineral deposit tabulated in the use matrix of an input-output table. Under existing accounting procedures, GDP would be the total value of all domestic goods produced for final demand -- 80 units worth of machinery in this example -- which would in this case be equal to the aggregate value added (Butterfield 1990: 5). In the revised table, a ten unit deduction from GDP is added to the table to account for mineral depletion. A row has been added to the commodity inputs to keep record of the sales of minerals, the sum of which is ten units. This value is then deducted from final demand to yield a revised GDP figure

TABLE 3 Mineral Resources in a Revised Input-Output Account

		Use			Final Demand		Total Output
		Mining Industry	Metal Industry	Machinery Industry	Mineral Depletion	Business Investment	
Commodity Input	Ore		20				20
	Metal			40			40
	Machinery					80	80
	Mineral Deposit	10			-10		
Value Added	Labour	5	10	20			35
	Operating Surplus	5	10	20			35
Total Industry Output		20	40	80	-10	80	70

Source: Butterfield (1990).

of 70 units. Butterfield (1990) recommends that this negative amount should also be explicitly tabulated in the capital account of the mineral industry.

Unlike the majority of resource accounting frameworks which feature monetary accounting and alteration of macro-accounting aggregates, Butterfield advocates direct adjustments to GDP.[7] He counters the argument that GDP is to reflect the aggregate of domestic economic production including capital consumption with the idea that natural capital, that is, resource input, is not truly analogous to domestic human capital input, originating as it does outside the domestic economy. He argues instead that natural capital is akin to non-competitive imports, the value of which is not a component of GDP. Butterfield further establishes that natural capital is unlike human capital in that it is often transformed by the forces of production.

The notion of a transfer of wealth from the environment to the economy is reminiscent of Bartelmus's (1990) proposals. However the actual SEEA (Bartelmus et al. 1991; UNSO 1990) restricts this transfer of wealth format to the addition of reserves to the asset balance sheets; the value of actual depletion is deducted from NDP as a part of the eco-margin.

Butterfield is not alone in recommending that adjustments be made directly to GDP. While his arguments correspond most closely to those of Bartelmus (1990) in this regard, another notable advocate of adjustments to GDP for depletion of resources is El Serafy (1989). In addition to devising a formula for the separation of net returns from non-sustainable resource extraction into

7. Harrison (1989) discusses the pros and cons of adjustments to NDP versus GDP.

sustainable income and capital maintenance components, El Serafy reasoned that the adjustments be made to GDP rather than NDP. He grounds this argument on the basis that GDP is a more reliable and thus more widely used aggregate; adjustments made to GDP could thus be more efficacious in their policy impact. Perhaps unwittingly, El Serafy provides ammunition to his detractors with this point in as much as the perception of reliability in the GDP formula makes it unlikely that any contentious adjustments such as his own would be adopted. Moreover, Harrison (1989) logically points out that the "G" in GDP stands for "gross". While the resolution of this particular point is beyond the scope of this paper, two observations merit consideration pursuant to Butterfield's framework. First, the choice of adjusting GDP or NDP is a non-trivial one not to be taken lightly. Second, Butterfield has shown that natural resource accounting can be fully integrated in a manner that largely preserves the current conventions if economists, accountants and other users of the SNA are willing to adopt certain structural changes.

The French Patrimony Accounts

The French system of resource accounts, called the patrimony accounts, is arguably the most complex and comprehensive system yet devised. Originally the patrimony accounts were intended to provide a database by which the aggregates in the SNA could be corrected for natural resource depletion. However, as the program developed, it was recognised that subordinating the accounts to the SNA perhaps overemphasized economic goals (Theys 1989), to the detriment of other uses for these environmental statistics. A change of direction occurred, and the system that has evolved is intended more to serve a broad array of purposes by providing a variety of different disciplines a common environmental database in both quantitative and qualitative forms. The attempt was to facilitate a broader and deeper understanding of the multitudinous relationships between human societies and the natural environment (Theys 1989). The French system is thus designed to bridge the gap between the two major emphases of resource accounting identified previously.

The general structure of the French patrimony accounting system is presented in Figure 2. Core accounting themes include components (non-renewable, physical environmental and biotic as represented in boxes 1, 2 and 3), ecosystems (box 4), agents (box 5) and territories (box 6). There are also accounts in the French system which act as satellite accounts to interface with other information systems, for example, the SNA. These various themes reflect the French desire to examine resources from three perspectives: 1. in terms of components of larger systems, 2. in terms of the systems themselves, including a spatial component, and 3. from the perspective of the resource user. Resource accounts compiled pursuant to these various themes are of two generic formats, called respectively central accounts and peripheral accounts (Weber

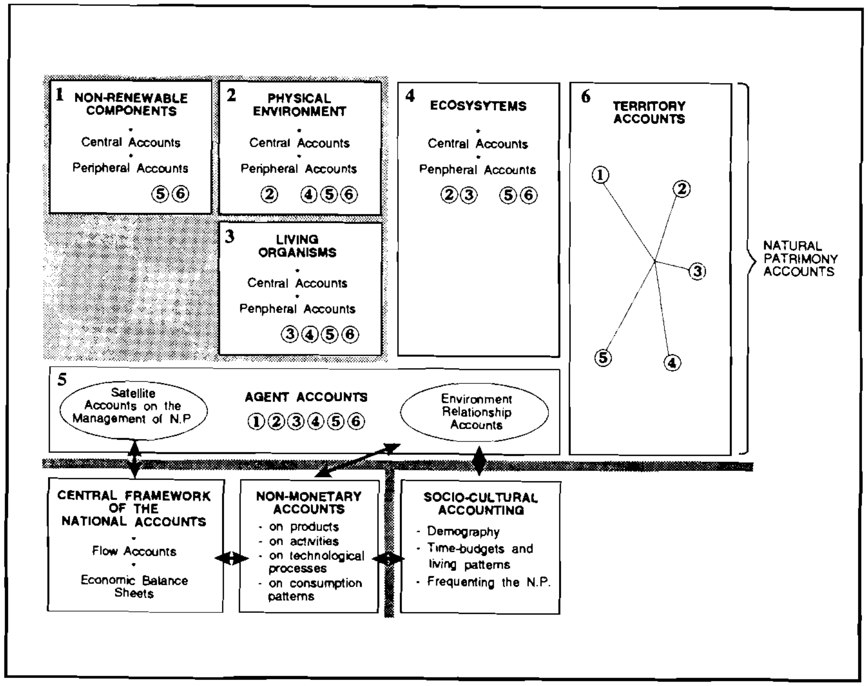

Figure 2 The French Patrimony System

1983; Vanoli 1986). The circled numbers in Figure 2 refer to the box numbers, and describe the scope of the system. For example, a circled 5 in box 1 means that agent accounts are compiled for non-renewable components. The absence of a circled 2 in box 3 means any relationship that exists between non-renewable components (like petroleum resources) and the physical environment is not relevant to a resource oriented accounting system.

The central accounts are essentially the core of the patrimony system. They are intended to provide information on the quantity of a component or ecosystem at the beginning of the accounting period and at the end (the suggested interval is five years), as well as tabulate any specific flows. Each central account can have three components: an overall equilibrium account, a use account and the aggregation account.

Overall equilibrium accounts are the French analogues of the Indonesian accounts constructed by Repetto et al. (1989), with the notable difference that overall equilibrium accounts do not necessarily have to contain monetary entries; the appropriateness of economic components of an equilibrium account is dependent upon the type of central account (agent, ecosystem or component) as well as the nature of the relationship between the subject of the account and society. The structure of the equilibrium accounts, while containing certain fixed aspects, is flexible; columns may be added or deleted where appropriate.

TABLE 4 Central Account for a Commercial Forest 1969-79 (units in thousands of cubic metres)

Resource or Asset	Broadleaf	Coniferous	Total
Opening stock (1969)	980.1	6,526.5	7,506.6
Growth	401.9	2,583.5	2,985.4
Recruitment			
Total	1,422.2	9,368.4	10,790.6
Use			
Mortality	5.6	21.0	26.6
Catastrophic loss	9.7	481.2	490.9
Harvest	92.0	1,474.0	1,566.0
Self-consumption	13.6	395.0	408.6
Adjustment	-29.4	1,239.2	1,209.8
Closing Stock (1979)	1,330.7	5,758.0	7,088.7
Total	1,422.2	9,368.4	10,790.6

Source: Adapted from Theys (1989).

Table 4 provides a specific example of the equilibrium portion of a central account for forestry. Overall equilibrium accounts are the basis of the central accounts in that use accounts and aggregation tables are optional addendum.

The use account component of a central account consists of relatively detailed information about the human uses and natural consumption or production of the subject of the account. Essentially this consists of a more disaggregate version of the resource availability column of the equilibrium account.

Weber (1983) has stipulated that environmental data are useful if they adhere to two basic criteria: 1. data should conform to a common standard and 2. the database should feature a manageable number of aggregates for digestion by policy-makers (for example, State of Environment reporting). In order to produce these aggregates, central accounts may also contain aggregation tables or summary compilations of resource status and use. However, aggregation is notoriously difficult to accomplish without reducing disparate physical phenomena to common units of measure, a practice that carries with it its own distinct shortcomings. Weber (1983: 435) maintains that aggregation tables are completed when "...a relatively vast and homogeneous set of components or ecosystems is presented."

Peripheral accounts are so named because they serve the function of linking various central accounts with one another. Because central accounts can be linked in that the flux of a component or ecosystem will influence other ecosystems, peripheral accounts are designed to make these links more explicit. Applications include water-forest peripheral accounts and water-vegetation peripheral accounts (Weber 1983). Peripheral accounts might best be thought of as scientific explorations into modelling with greater precision the relationships between ecosystems, components and agents.

A complete assessment of the patrimony system is difficult given that the French have undertaken implementation in incremental fashion. This is due in no small part to the complexity of the system and to the onerous data requirements of a complete implementation (IREE 1990). On the one hand this very complexity could be considered a flaw in the design of the accounts, in light of the Norwegian experience with efforts expended on little-used databases. On the other hand, it seems difficult to avoid complexity when one wishes to compile a multi-objective database, that is, one that subsumes purely economic rationales, something the French have attempted to do (see Figure 2). This is especially true for physical accounting in which case there is no homogeneous metric for broad aggregation. One way to mitigate the unwieldiness of complex resource accounting systems is to build into their designs flexibility for incremental implementation, a feature that should support flexibility in a multi-objective capacity as well.

Conclusion

This review does not exhaust the list of institutional nor independently formulated resource accounting structures. This collection has been selected in order to present 1. those deemed most influential in their various emphases and constructs; and 2. those which represent a full spectrum of emphasis from exclusively physical accounting to those whose main emphasis is supplementing the SNA with monetary resource accounts.

While Peskin and Lutz (1990) have identified the SEEA and similar proposals by Peskin (1989a and 1989b; Peskin and Peskin 1978) as integrated, here the French patrimonial system occupies the central portion of the spectrum. This divergence is a function of two main points. First, integration necessitates decoupling the core structure of a natural resource accounting system from the structure of the SNA. This is because, as Gilbert (1990) has pointed out, the uses to which natural resource accounts can be put subsume SNA-based policy and planning. Thus, in order to facilitate multi-objective planning, resource accounts should be constructed independently of the SNA. The overriding purpose of the SEEA is to supplement the SNA, whereas the French system is largely independent of the macro-economic accounting system, with linkages to a satellite system in turn supplementing the SNA (Theys 1989). Secondly, the physical and monetary accounts should be decoupled from each other. Again, this is in order to facilitate pluralistic application of resource account information. This is not a feature of the SEEA which, while including extensive provisions for physical accounting, does not commit to these as an independent facet of the framework. Again the French system serves as a contrast, with emphasis on the provision of disparate types of information in both qualitative and quantitative forms (Theys 1989). The need to decouple physical and monetary accounts is further supported by the pervasive weaknesses in virtually all methods of resource valuation, including market methods. Physical data cannot only serve as a basis for pluralistic valuation techniques, but also as direct data input for applications that do not require valuation.

The pluralistic nature of the patrimonial system is not without its costs; implementation of the French accounts has proven very slow and incremental in nature (IREE 1990). This suggests that a successful framework should be designed in such a manner that implementation by degree would provide useful results, for example in the form of case accounts. The structure of the French system suggests this possibility, particularly if primary emphasis is placed upon the completion of equilibrium accounts for so-called core resources such as timber, fish, soil and subsoil assets. At any rate, while step-by-step implementation of the framework should be enabled by system design, a concurrent feature should be the identification of priority areas for initial work. Specific priority areas should be a function of the needs of potential users in light of the Norwegian experience (Aaheim et al. 1991).

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