PART V

PROGRESS IN MEASURING SUSTAINABLE DEVELOPMENT

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21 Environmental accounting

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1. OVERVIEW OF ENVIRONMENTAL ACCOUNTS

Sustainable development is the stated objective of many countries and the search for operationalizing this concept has focused in part on the System of National Accounts (SNA). The SNA is crucial in the quest for sustainable development because it constitutes the primary source of information about the economy and is widely used for assessment of economic performance and policy analysis throughout the world. Sustainable development begins with monitoring and the information needed to design effective policy. The most recent version of the SNA 2008 (EC et al., 2009) has begun to address this, but the well-known shortcoming regarding the treatment of depletion remains. The SNA 2008 includes guidelines for incorporating natural resource assets in the national balances sheet, but does not yet address depletion of these assets. Thus, while the income from extracting minerals is recorded in the national accounts, the simultaneous depletion of mineral reserves is not. Uncultivated fisheries and forests receive similar treatment, in contrast to the treatment of cultivated fisheries and forests. This can result in quite misleading economic signals about sustainable national income. Indeed, one of the primary motivations for the early environmental accounting efforts in the mid-1980s was concern that rapid economic growth in some developing countries was achieved through liquidation of natural capital, a practice that appears to boost GDP in the short run, but is not sustainable in the long run.

Equally important, ecosystems provide non-marketed goods and services that are often not fully included in national accounts, or are wrongly attributed to other sectors of the economy. For example, the harvest for own use of firewood and wild foods, so critical to livelihoods in many developing countries, is often underestimated. Forests also provide recreation and tourism services, which are not attributed to forestry when there are no market prices to represent these services. Forests may also provide watershed protection benefiting agriculture, hydroelectric power, municipal water supply, and other sectors, but, absent market prices, the value of these services is not recognized and, hence, not attributed to forestry. Thus the total benefits from sustainable forestry are underestimated, and other sectors of the economy are not fully aware of their dependence on the health of this natural resource.[1]

A milestone in better accounting for natural capital was reached in 2012 when the UN Statistical Commission adopted as an international statistical standard the *System of Environmental and Economic Accounting – Central Framework* (SEEA-CF), like the System of National Accounts.[2] This achievement is the culmination of the conceptual work and empirical applications by national and international agencies, academics and NGOs over several decades to develop environmental accounts as a tool to promote sustainable development. Interim guidelines were produced along the way (UN, 1993; UN

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et al., 2003). Specialized manuals for specific resources are under preparation, with one for water (UN, 2006) already adopted by the Statistical Commission. Separate volumes of the SEEA on Experimental Ecosystem Accounting as well as one on Applications and Extensions were finished in 2013 (UN, 2013a, 2013b).

The SEEA provides a comprehensive and broadly accepted framework for incorporating the role of the environment and natural capital in the economy through a system of satellite accounts to the SNA. As satellite accounts, the SEEA has a similar structure to the SNA, consisting of both stocks and flows of environmental goods and services. The SEEA-CF has four major components, which are constructed, wherever possible, in both physical and monetary units:

- Asset accounts that record the volume and monetary value of stocks and changes in stocks of natural resources, including a measure of asset depletion.[3]
- Physical flow accounts for materials, energy and pollution, which provide information at the industry level about the use of energy and materials as inputs to production and consumption, and the generation of pollutants and solid waste. In contrast to the interim version of SEEA written in 2003, the SEEA-CF does not address valuation of emissions or environmental degradation.
- Environmentally related transactions. These accounts for environmental protection, resource management expenditure, and other environmentally related transactions reorganize information already in the SNA to make more explicit (1) expenditures incurred to protect the environment and manage natural resources; and (2) taxes, fees and other charges, and property rights related to the environment.
- Macroeconomic indicators and aggregates that map the detailed accounts through the sequence of accounts to produce measures of macroeconomic performance and sustainability. From the flow accounts, these include, for example, Depletion-adjusted Net National Income and Depletion-adjusted Net Savings. The natural resource asset accounts also can be integrated into the national balance sheet to provide a more comprehensive measure of national wealth

The SEEA 2003 included an extended discussion of different methodologies for valuation, not just valuation of natural resource assets, but more importantly, valuation of environmental damage and degradation, and to a limited extent, the valuation of services like carbon sequestration. The SEEA-CF only includes the asset value of natural resource assets because it was not possible to find consensus on the extended application of valuation in the national accounting context. Valuation of ecosystem services and environmental degradation is now addressed in SEEA Experimental Ecosystem Accounts (volume 2). SEEA volume 2 addresses:

- Land accounting in an ecosystem context. While ecosystem accounts are mentioned in the SEEA-CF, a much more extensive treatment of land accounting to represent ecosystems is provided in this volume.
- Approaches to valuation of ecosystem services and degradation. Different approaches to valuation of non-market ecosystem services and degradation are considered here, with a focus on consistency with valuation principles of the SNA, as well as the resulting sequence of accounts, if valuation were to be implemented.

Table 21.1 Countries with environmental accounting programmes

	1. Assets (physical & monetary	2. Flow accounts for pollutants & materials		3. Environmental protection & resource management expenditures	4. Macro-economic indicators
		Physical	Monetary		
1. Countries with regular environmental accounts:					
Australia	X	X		X	monetary
Canada	X	X		X	
Colombia		X	X	X	
EU-27*	X	X		X	physical
Korea	X	X	X	X	monetary
Mexico	X	X	X	X	monetary
New Zealand	X	X	X		
Norway	X	X			
South Africa	X				
2. Countries initiating environmental accounting, or renewing earlier pilot programs: Botswana, Brazil, Chile, Costa Rica, Guatemala, Indonesia, Madagascar, Mauritius, the Philippines, Qatar, Rwanda, Vietnam					

Notes: * EU member countries are required to report on air emissions, material flow accounts and environmental protection expenditures. Accounts for water and asset accounts for oil and gas, and forests are widely implemented.

Environmental accounts are now constructed regularly by many developed countries and a few developing countries (Table 21.1). Many of the pilot efforts to implement the SEEA in developing countries did not result in institutionalization by those countries, for reasons to be considered at the end of this chapter. Environmental accounts are a broad undertaking and countries have implemented them on a modular basis, compiling the parts of the accounts that are most useful for their environmental priorities. Environmental accounts improve policy-making by providing aggregate indicators for monitoring environmental–economic performance, as well as a detailed set of statistics to guide resource managers toward policy decisions that will improve environmental–economic performance in the future.

This chapter describes some of the policy applications for each component of the environmental accounts. Detailed reviews of applications can be found in a number of reports: an early, comprehensive review is provided by Lange (2003); a conceptual overview published as a third volume of the SEEA (UN, 2013b); Australia recently published a review of its experiences with environmental accounting over the past 20 years (ABS, 2012) and the Netherlands publishes an annual report on its environmental accounts (for example, Statistics Netherlands, 2012). Other countries include information about their environmental accounts as part of other regular publications. For technical aspects of environmental accounting, the reader is referred to EC et al. (2012).

The countries listed are those with environmental accounting programmes by government agencies. An extensive range of environmental accounting case studies are available for many other countries, but mainly as an experimental or one-time study rather than on-going work by a government agency.

2. ASSET ACCOUNTS: MONITORING TOTAL WEALTH

A key component of the SEEA is to monitor natural capital assets. A considerable body of theoretical work (for example, Arrow et al., 2003; Asheim and Weitzman, 2001; Dasgupta and Mäler, 2000 and 2004; and Hamilton and Clemens, 1999) has demonstrated that sustainable development requires non-declining per capita wealth, where wealth is defined in a comprehensive manner to include produced, natural, and human and social capital. This implies that economic development can be viewed as a process of 'portfolio management' seeking to optimize the management of each asset and the distribution of wealth among different kinds of assets (World Bank, 2011).

Environmental accounts provide an agreed methodology for measuring the natural capital component of Comprehensive Wealth accounts over time and associated macroeconomic indicators such as Adjusted Net Savings and Adjusted Net National Income. These indicators, which measure whether depletion of resources is compensated for by investment in other assets, can monitor whether development is sustainable or not (see for example, UNU and UNEP, 2012; World Bank, 2011). These trends in comprehensive national wealth can also be analysed to assess characteristics important to economic development, such as the diversity of wealth, ownership distribution, and volatility due to price fluctuations, an important feature for economies dependent on primary commodities (see Lange, 2003; UN, 2013b for a discussion of this issue and some examples).

A total of 18 countries, mostly developed countries, regularly compile asset accounts for at least one type of natural resource. Of these, six include natural capital as part of their official national balance sheets, notably Australia and Canada (see Table 21.2 and World Bank, 2011 for a review of country implementation of asset accounting and incorporation in national balance sheets). Accounts for minerals and energy, especially oil and natural gas, are most common, followed by timber and land accounts. Mexico stands out as the only developing country with a long-term programme of asset accounting; earlier

Table 21.2 Natural capital in Australia's national balance sheet, 2006 to 2010 (current AUD prices)

Capital estimate	2006 $billion	2007 $billion	2008 $billion	2009 $billion	2010 $billion
Produced capital[a]	3271.3	3553.9	3843.6	4048.0	4227.8
Net financial assets with the rest of the world	−528.7	−613.2	−658.5	−703.7	−776.9
Natural capital (partial)	3117.4	3512.3	3773.4	3936.1	4574.3
– land	2798.4	3156.2	3367.6	3297.2	3963.7
– subsoil minerals and energy	302.9	335.8	385.5	615.8	590.5
– native timber	2.1	2.1	2.1	1.9	1.7
– plantation timber	7.9	8.4	9.9	9.3	9.4
– wild fish	6.1	9.8	8.3	11.9	9.0

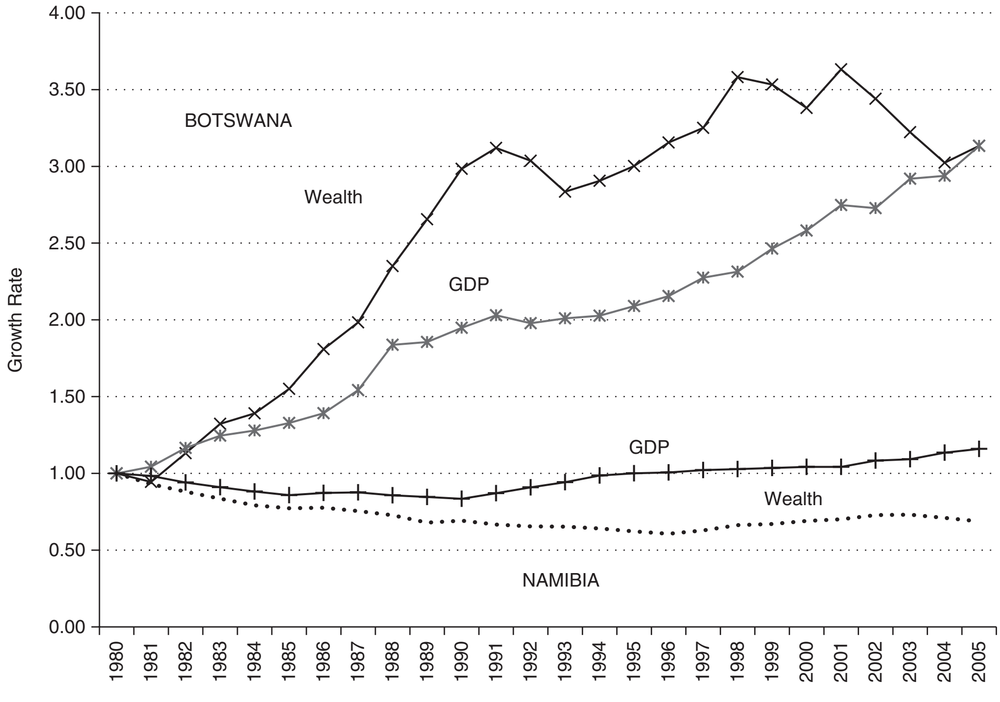
Note: a. Excludes plantation timber inventories, which are included in natural capital.

Sources: Australian System of National Accounts (ABS cat. no. 5204.0) and Completing the Picture: Environmental Accounting in Practice (ABS cat. no. 4628.0.55.001).

pilot programmes in a number of other countries, such as Botswana and the Philippines, are being reinstated, in part because of the new clarity on methodology now provided by the SEEA-CF.

In addition to providing indicators for monitoring sustainable development, natural capital accounts provide information that is useful for managing resources. Resource-rich economies face a particular development challenge: transform natural capital into other forms of productive wealth, a process that requires good policy in three critical areas: (1) promotion of efficient resource extraction to maximize resource rent; (2) recovery of the rent by an agency capable of investing rent; and (3) efficient investment of rent. Environmental accounts provide more detailed information to assess the policies guiding this process: the amount of resource rent being generated from each resource, the amount of rent recovered by various institutions (for example, government, private sector; domestic or foreign), and the share of that rent, if any, that is invested in other assets.

Both Botswana and Namibia, for example, have significant natural capital: diamond mining accounts for roughly a third of Botswana's GDP; mining and fishing account for over 20 per cent of Namibia's GDP. But only Botswana has been successful in using its natural capital to increase national wealth, moving it into the ranks of upper middle-income countries. Namibia's wealth and income have lagged considerably behind that of Botswana (Figure 21.1).



Source: Adapted from Lange (2004).

Figure 21.1 Growth of real, per capita wealth and national income in Botswana and Namibia, 1980 to 2005 (1980 = 1.00)

The rapid growth of national wealth in Botswana is consistent with its development policy, which set a goal of improving living standards and reducing poverty based on investment of mineral revenues (see Lange and Wright, 2004). Recovery of resource rent and reinvesting it in alternative assets is the key to sustainable development in resource-rich countries. Botswana has recovered much of the resource rent generated by its minerals (averaging 75 per cent of rent generated, Figure 21.2) and has consistently reinvested virtually all of it. Namibia has had a harder time; rent generation has been more volatile, and government has not recovered such a large share of the rent. In contrast to Botswana, Namibia has had no explicit policy regarding reinvestment of revenues from natural capital (see Lange, 2004; 2008 for discussion).

Management of natural resources for long-term growth is a challenge that many countries face, and may be especially challenging for developing countries where resource rents may be high, the pull for current consumption over investment for the future may be especially strong, and institutions weak. Natural resource rents are at least 8 per cent of GDP for all developing country regions except south Asia (Figure 21.3).

3. FLOW ACCOUNTS FOR ENERGY, MATERIALS AND POLLUTION

The flow accounts of the environmental accounts are compiled and used for economic analysis far more extensively than the asset accounts. The 27 European Union member countries are required to report on air emissions, material flow accounts and environmental protection expenditures; accounts for energy, water and asset accounts for oil and gas, and forests are also widely implemented. The widespread implementation by the EU has helped to push the implementation and standardization of environmental accounts. These accounts also provide macroeconomic indicators of sustainability as well as more

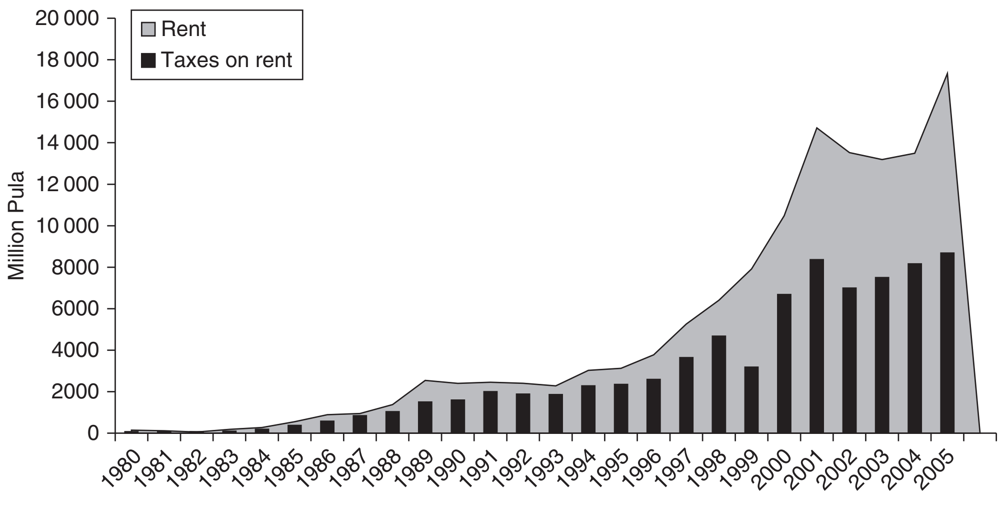
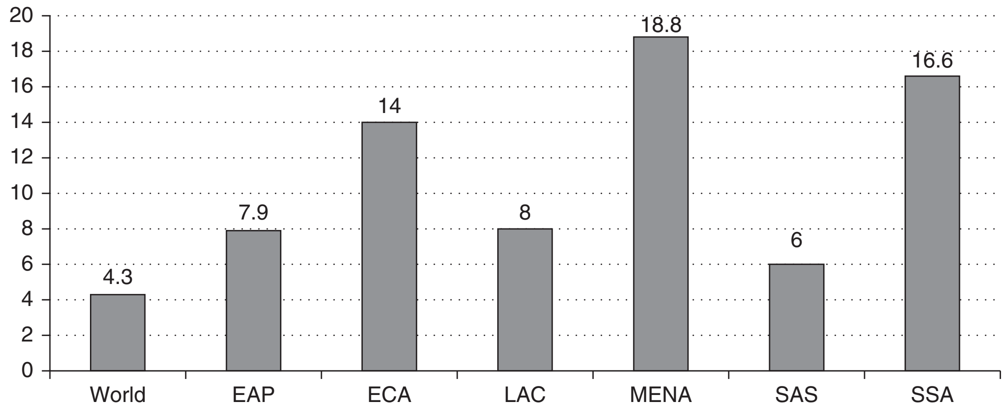


Figure 21.2 Resource rent from minerals and rent capture through taxes in Botswana, 1980 to 2005



Notes:
Figures include only developing countries, not high-income countries. Figure for the world includes all countries.
EAP (East Asia and Pacific); ECA (Europe and Central Asia); LAC (Latin America and Caribbean); MENA (Middle East and North Africa); SAS (South Asia); SSA (sub-Saharan Africa).

Source: Calculated from World Bank data.

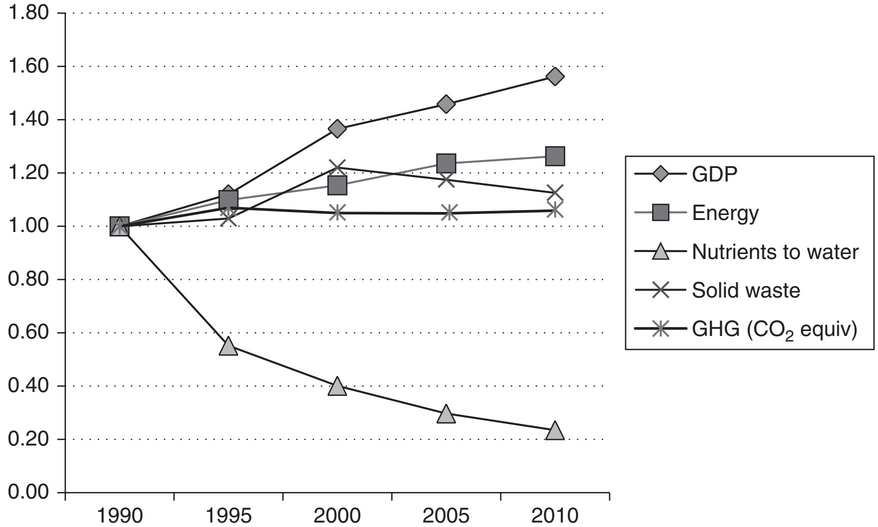
Figure 21.3 Resource rents as a percentage of GDP in developing regions and the world, 2010

detailed information to support economic analysis of sources of environmental pressure and options for change that can be used to improve sustainability. The aggregate indicators provide an overview of the relationship between economic development and the environment; the more detailed accounts help explain the overview.

The flow accounts consist of three components: physical accounts for the supply and use of material and energy resources; physical accounts for the emission of pollutants; and monetary accounts for environmentally related transactions. The physical accounts help set priorities for policy based on the volume of resource use, pollution and other factors. They are also used in economic models to evaluate options for development and specific policy instruments for implementing a given development strategy, such as green taxes. Monetary accounts would be useful to inform decision-making about the relative costs and benefits of reducing pollution, resource use and other factors, but are not part of the SEEA-CF; the question of valuation is taken up on an experimental basis in SEEA volume 2.

Physical Accounts

At their simplest, the flow accounts are used to monitor the trend over time of environmental goods and services, and pollution emissions, both total and by industry. Such indicators are useful for monitoring an important policy concern: decoupling economic growth from material and energy use. An example from the Netherlands shows substantial decoupling of GDP growth from energy and pollution over the period 1990 to 2010 (Figure 21.4).



Source: Statistics Netherlands (2012, p. 11).

Figure 21.4 Index of growth of GDP, energy use, emissions of nutrients into water, solid waste and greenhouse gas emissions in the Netherlands, 1990 to 2010 (1990 = 1.00)

The construction of environmental–economic profiles, or 'eco-efficiency' indicators has become a common way of monitoring sustainability, and is also used for benchmarking industry performance. These descriptive statistics provide a first approach to identifying major users of resources and sources of emissions, and provide a comparison of each sector's relative environmental burden and economic contribution. Typically, eco-efficiency indicators report an industry's percentage contribution to the national economy (value-added, employment) alongside its environment impact such as emissions of various pollutants. A similar sector-level indicator is the 'resource productivity indicator' calculated as materials (energy, water, etc.) or pollution per unit of value-added (see example from the water accounts for Australia in Table 21.3).

While the eco-efficiency indicators report the *direct* generation of pollution associated with production, it is useful for policy-makers to understand the *driving forces* that result in such levels of pollution. The driving forces for economic production are the final users. Input–output analysis has been used to measure the total impact (direct + indirect) of a given final use. This approach is especially useful in understanding the effects of different patterns of household consumption or trade on the environment.

Economic Modelling with Environmental Accounts

Assessment of trade-offs in a partial equilibrium framework is a first step towards understanding the policy impacts on the environment. But understanding the impact of broader changes usually requires an economy–wide environmental–economic model.

Table 21.3 Water profile and water productivity, Australia, 2010–2011

	Water use ML	Industry gross value-added AU$million	Water productivity GVA/ML water use
Agriculture	7175	40695	6
Forestry and fishing	175	27727	158
Mining	540	285813	529
Manufacturing	651	238917	367
Utilities	1868	129139	69
Other industries	1227	2524200	2057
Household	1699	NA	NA
Total	**13337**	3246491	243

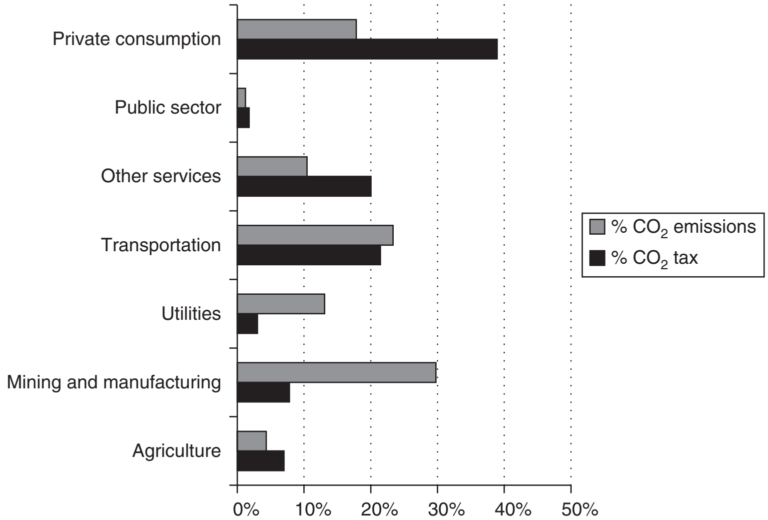
The third volume of the SEEA, Extensions and Applications (UN, 2013b), describes a range of analytical and modelling applications. At the core of most of these techniques is an environmentally extended input–output table (EE-IOT) which can be used for simple multiplier analysis as well as in more complex models such as computable general equilibrium models.

One of the most important areas of application for environmental accounts is economic planning and scenario analysis. Planning for sustainable development requires an integration of environmental and economic modelling. In the past, it was difficult to integrate environmental and economic planning because the underlying database for such models did not exist. The contribution of environmental accounting is to provide the economist with a consistent, systematic and reliable set of accounts that are linked to the economic accounts. While this topic is too broad to review in detail here, examples of widespread modelling applications include: modelling of environmental taxes and resource user fees; modelling trade and the environment including issues like 'virtual water'; modelling environmental impacts of long-term consumption patterns, demographic trends and development strategies on energy and water demands and generation of pollution, including low-carbon growth strategies. Reviews of the many uses of EE-IOT in various modelling frameworks can be found in Hoekstra (2010), Wiedman (2009) and Wiedman et al. (2007).

4. ENVIRONMENTALLY RELATED TRANSACTIONS

This component of the environmental accounts takes figures that are already included in the SNA and rearranges them to make them more useful for policy. It includes accounts for environmental taxes and related fees, and accounts for environmental protection expenditure and natural resource management. This set of accounts has become particularly important in the European Union, where it is one of the components of the SEEA that member countries are required to report on.

Many countries levy taxes related to greenhouse gas emissions. Sweden has compared the share of carbon emissions by industry and households to the share of carbon taxes paid (Figure 21.5). If a carbon tax is administered equally on the basis of CO_2 emitted, the two shares should be the same for an industry. While there is rough parity



Source: Compiled from data obtained from Statistics Sweden website, http://www.scb.se/Pages/ProductTables38186.aspx.

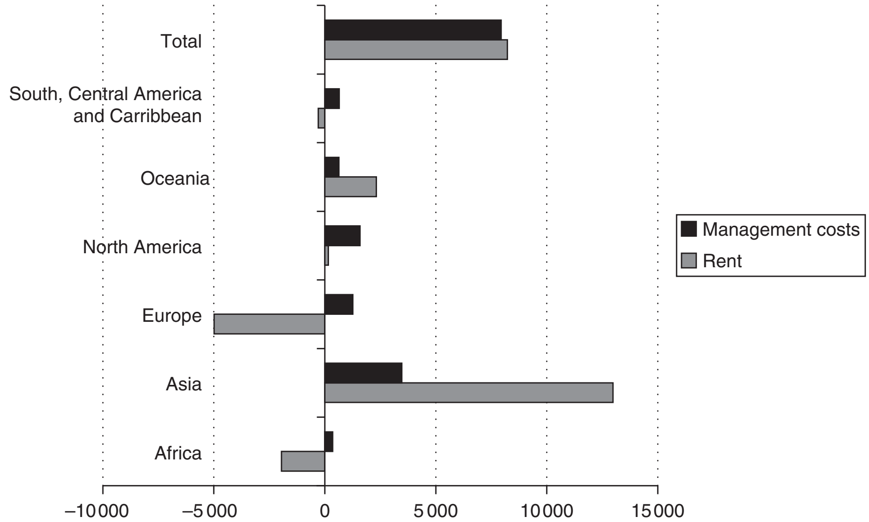
Figure 21.5 Carbon emissions and carbon taxes by industry in Sweden, 2008

in transportation, an energy-intensive sector, that is not the case in other sectors. Households pay a much greater share than the share of CO_2 they are directly responsible for, while manufacturing pays much less.

Management of a natural resource can generate rents, as described in section 2. At the very least, rent recovery by government should be sufficient to at least cover the costs of managing the resource. In the case of non-renewables, the management cost to government is often relatively low[4] and much of the cost can be shifted to the private sector. But in the case of renewable resources like forests or fisheries, governments often incur considerable expenses to ensure sustainable use of a resource. Global fisheries are a well documented case of an imbalance between rent generated and management costs incurred by governments. The majority of the world's marine fisheries are subsidized and generate no rent, let alone enough to pay for management costs. An estimate by region of the rent generated and the resource management costs is shown in Figure 21.6.

Ecosystem Accounts

Accounting for ecosystem services is especially important for developing countries for several reasons. Developing countries contain most of the world's biodiversity; biodiversity protection services benefit not only local communities but also the global community. Ecosystem services, such as water and soil protection, are often under greatest threat in developing countries, but these countries often have fewer resources to cope with loss of ecosystem services (flood control, water purification, increased health care, and so on). In addition, the well-being of developing countries may be more vulnerable to loss of



Source: Sumaila et al. (2013).

Figure 21.6 Fisheries resource rent and management costs by region, 2005 (millions of US dollars)

these services as a majority of people depend directly on ecosystem health, (for example, soil stability for subsistence farming, fisheries habitat) and often have limited alternative sources of livelihood. Noting that the poor are often those most vulnerable to deterioration of natural systems, the *Millennium Ecosystem Assessment* states that 'development policies aimed at reducing poverty that ignore the impact of our current behavior on the natural environment may well be doomed to failure' (Millennium Assessment Board, 2005).

The simplest approach to ecosystem accounting is a variation of spatial economic accounts, common in regional economics, where the spatial area of interest is defined in terms of ecosystem concepts. One example is *The Economic Description of the North Sea for the Netherlands* by Statistics Netherlands (2010), which reports industry production, intermediate consumption, value-added, and employment for the coastal and marine environment. A similar approach is the experimental water accounts for the Murray-Darling River Basin in Australia (ABS, 2012).

The SEEA Volume 2, Experimental Ecosystem Accounting, presents a more ambitious approach to ecosystems. The SEEA-CF starts from the perspective of the economy and incorporates information about natural resource inputs, emission of pollutants, and associated natural resource assets. In contrast, SEEA Experimental Ecosystem Accounting starts from the perspective of ecosystems, building on land use/land cover accounts and links ecosystems to economic and other human activity. Australia has done the most work in ecosystem accounting so far, with experimental accounts for watersheds in the states of Victoria and Queensland.

Experimental land accounts have been compiled for the state of Victoria where a programme has been established to pay for ecosystem services provided by the native vegetation on private land. A reverse auction system is in place and provides some information about the 'value' of these ecosystem services.

Land accounts in Queensland were constructed in order to help improve management of the Great Barrier Reef (GBR) Marine Park, a globally significant coral reef and World Heritage site, or great economic as well as heritage value, generating around A$2257 million from tourism in 2010. While the coral reef itself has been subject to careful management, many of the threats to this valuable ecosystem originate outside the GBR, especially from land use practices around the rivers which drain into the sea near the GBR. Agriculture practices (for example tillage methods and volume of fertilizer applied) have a particularly strong impact on water quality. Sustainability of the GBR requires integrating management of the catchment and the marine ecosystem.

To help manage the GBR for long-term protection and sustainable use, the Great Barrier Reef Land Account was constructed. The GBR Land Account provides detailed environmental, economic and social information for each of the five Natural Resource Management regions of the GBR catchment. The Land Account includes data on land cover and land use, identifying major sources of nutrient and soil runoff due to land use and management practices, as well as the economic and social dimensions such as land value, crop value and employment. Together with hydrological and other data, water use and pollution emissions to water are estimated (see Table 21.4). The Land Accounts then can be used to monitor areas and activities that may impact on the reef as well as the economic cost and impact of constraining these activities. Additional accounts for biodiversity (species abundance) and carbon have been added.

The accounts proved unexpectedly useful for disaster management following heavy

Table 21.4 Water use and emissions to water by region from the land accounts for the Great Barrier Reef, Australia

	Wet Tropics	Burdekin	Mackay-Whitsundays	Fitzroy	Mary Burnett	Total Great Barrier Reef region
Water use (ML)						
Agriculture	165 063	495 430	170 435	233 517	202 925	1 267 370
Households	38 584	22 040	12 861	26 404	30 968	130 857
Other	37 511	97 911	27 257	115 240	69 724	347 643
Total	241 158	615 381	210 553	375 161	303 617	1 745 870
Water pollutants						
Total suspended solids (ktonnes/yr)	1 360	4 738	1 542	4 109	3 076	14 825
Total nitrogen (tonnes.yr)	4 400	2 446	912	1 672	1 463	10 893
Total phosphorus (tonnes/yr)	2 037	2 555	2 172	4 142	3 092	13 998
PS11 herbicides (kg/yr)	10 054	4 911	10 019	2 269	990	28 243

Source: ABS (2012) and http://www.abs.gov.au/ausstats/abs@.nsf/mf/4609.0.55.001.

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flooding in Queensland, highlighting an important application of land/ecosystem accounts for many parts of the world. They were able to provide immediate estimates of economic impact of flooding damage on the state and national GDP, on output of specific sectors of the economy, employment and income.

Monetary Accounts

Effective environmental management is based not only on an understanding of the *volume* of environmental goods and services and pollution, but also an understanding of the *economic* implications. Policy-makers need to know, for example, what the welfare loss of pollution is (damage costs) and where limited financial resources will be most effective in reducing environmental pressure, that is, the relative benefits and costs of reducing different forms of environmental degradation from different sources. Similarly they need to know the value of damages from deforestation in terms of reduced productivity or increased production costs in other sectors of the economy.

In earlier work on environmental accounting, there was experimentation with valuation of ecosystem services and degradation by statistical offices in the 1990s. But valuation has been a highly contentious issue for the SEEA, with some organizations feeling that valuation did not fall within the scope or expertise of statistical agencies and, hence, did not belong in an accounting manual. Rather, it was viewed as part of the analytical use of the accounts. The consensus of statistical agencies was to exclude valuation from the SEEA-CF (except for asset valuation and depletion) and address it in SEEA Experimental Ecosystem Accounting. While there has been a great deal of activity to value ecosystem services and degradation (for example, see the compilation of studies under The Economics of Ecosystems and Biodiversity, or TEEB, at www.teebweb.org), it has not yet made its way into the national accounting framework via the SEEA. The SEEA-CF monetary accounts now include only the environmental taxes, subsidies and other related expenditures discussed earlier.

5. ECONOMY-WIDE INDICATORS OF SUSTAINABLE DEVELOPMENT

A wide range of macroeconomic indicators can be derived from the asset and flow accounts of the SEEA-CF; some of the major indicators are listed in Table 21.5. Many of these are indicators identified by the Green Growth and Green Economy Initiatives. The role of economic valuation in accounting, and the border between accounting and economic analysis are unresolved issues in the SEEA. Consequently, the SEEA does not make a recommendation for any particular indicators and presents both physical and the monetary macroeconomic aggregates that result from changes in natural capital assets.

Within the monetary macro-indicators, there is further controversy over whether sustainability is more accurately monitored from a national income approach such as environmentally adjusted GDP (for example, ABS, 2007; Muller and Mendelsohn, 2007) or from a wealth approach, for example Adjusted Net Savings compiled by the World Bank (2006; 2011) and the related Inclusive Wealth Index (UNU and UNEP, 2012). Australia's

Table 21.5 Macroeconomic indicators derived from the SEEA

Topic or issue	Indicator examples (state and trends)
1. Physical Indicators	
Environmental efficiency	Pollutant emission or waste generation intensities (or productivity ratios), relating the generation of residuals to economic output: ● Carbon productivity ● Air pollutant emission intensities ● Waste generation intensities ● Nutrient balance intensities
Resource efficiency	Resource use intensities (or productivity ratios), relating resource inputs to economic output: ● Material productivity ● Water productivity ● Energy productivity
Natural assets	Intensity of use of natural resource stocks, relating resource extraction to available stocks: water, timber, minerals, energy, fish Natural resource use index Land use and cover Soil productivity
Environment-related activities and instruments	Share of environmentally-related activities in the economy ● Output, investments, trade ● Employment Level and composition of environmentally-related expenditure ● Pollution abatement and control ● Biodiversity ● Resource management Environmentally-related tax rates and structures Environmentally-related subsidies
2. Monetary Indicators	
Management of resource-rich economies	Dependence of economy on natural resources ● Share of resource rent in GDP, from renewables and non-renewables ● Distribution of rent by institution, domestic and foreign
Monetary indicators of sustainability	Depletion-adjusted (da) macroeconomic aggregates: ● Product: daGDP, daNDP ● Income: daNNI ● Savings: daNet National Savings (Adjusted Net Savings) Wealth: National balance sheets extended for natural capital ● Value of total wealth over time ● Change volume and composition of wealth over time

depletion-adjusted GDP (Table 21.6) goes beyond the agreed depletion measures in the SEEA-CF by including not only subsoil asset depletion but also land degradation. Valuing land degradation is on the research agenda for the SEEA. These issues are addressed in more detail in other parts of this volume.

There are numerous additional indicators compiled by many groups to measure

Table 21.6 Depletion-adjusted GDP, Australia ($ million, current prices)

	2001–02	2002–03	2003–04	2004–05	2005–06
GDP	735 714	781 675	840 285	896 568	965 969
Net depletion	3 451	4 007	4 537	4 544	4 656
Subsoil depletion	*3 137*	*3 685*	*4 206*	*4 199*	*4 295*
Land degradation	*314*	*322*	*331*	*345*	*362*
Depletion-adjusted GDP	732 263	777 668	835 748	892 024	961 313

Source: ABS (2007).

sustainability, and many can be calculated using data from the environmental accounts, such as the Genuine Progress Indicator, or 'Footprint' indicators (ecological, water, carbon footprints).

6. THE FUTURE OF ENVIRONMENTAL ACCOUNTING

Environmental accounts make a great contribution to further integrating environmental and economic analysis by providing a single database that is consistent for both sets of information. The SEEA-CF, as an official handbook endorsed by the UN Statistics Committee, provides the basis for viewing environmental accounting as simply a more thorough way of doing national accounts. However, the SEEA-CF is far from a complete handbook providing clear standards on all issues, and a research agenda has been defined for issues that are within the framework of the SEEA-CF, including further work on depletion of natural biological resources, accounting for soil resources, and valuation of water resources.

The much broader agenda on valuation of ecosystem goods and services, including degradation, the resulting sequence of accounts, and macroeconomic indicators is the subject of a separate volume, *SEEA Experimental Ecosystem Accounting* (UN, 2013a). This has the advantage of achieving consensus on major areas of environmental accounting (SEEA-CF) by moving more contentious issues, like valuation, to SEEA Volume 2, where additional research can be done and tested out.

Accounting for Ecosystems

To respond to the demand for information about ecosystems, work on ecosystem accounting has begun but this is a very new field in accounting and requires integrating complex biophysical data with the provision of goods and services, and tracking how changes in the extent and characteristics of an ecosystem affect its capacity to provide these goods and services. Ecosystem accounting requires a shift in focus, from individual natural resources and pollutants related to economic activity, as in SEEA-CF, to a spatially-defined system producing multiple goods and services. SEEA Volume 2 provides the first version of an approach to ecosystem accounting. Many issues remain, such as defining and classification of spatial units and ecosystem services, to valuation and the sequence of accounts. Major empirical issues such as methodology to measure

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ecosystem services and the use of remote sensing need to be addressed. SEEA Volume 2 is far from an agreed standard, but provides a well-developed starting point for testing out methodology for ecosystem accounting.

NOTES

1. The increasing emergence of payments for ecosystem services, though still small, may provide an opportunity to incorporate such values, as the markets bring these services into the scope of the SNA. Particularly important for this development is the programme of payments for carbon sequestration under Reduction of Deforestation and Degradation (REDD), where the amounts of money under discussion are significant.
2. The Statistical Commission stressed that there was need for more testing of the SEEA-CF, in contrast to the SNA, which was adopted over 50 years ago.
3. Asset valuation follows the method in the SNA 2008, but the SEEA-CF goes further by defining a measure of depletion, which the SNA does not.
4. Monitoring and dealing with pollution from mining can be a serious management challenge if not carefully built into the mining agreement with the private operator from the beginning. Small-scale, artisanal mining may also require extensive involvement in management by government.

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