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ENVIRONMENTAL–ECONOMIC ACCOUNTING: PROGRESS AND DIGRESSION IN THE SEEA REVISIONS

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The 1992 Earth Summit and its message of sustainable development drove the launching of a System for integrated Environmental and Economic Accounting, the SEEA. Since then, sustainable development and the SEEA have given way to green growth and green economy indicators in the latest 2012 Summit. A lengthy revision process has now produced a curtailed "SEEA central framework." The new framework focuses on expenditures for environmental protection and resource management, and stocks and flows of "economic" resources; both are covered by the conventional national accounts. Environmental degradation, notably from pollution, is left to "experimental" ecosystem accounts. Further revision of the SEEA should reverse this retrenchment from integrative environmental–economic accounting. A comprehensive satellite system, rather than a limited statistical standard, might put the SEEA back on the policy agenda.

JEL Codes: Q51, Q56

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1. Introduction: A Historical Sketch

The System for integrated Environmental and Economic Accounting (SEEA) was born in this journal (Bartelmus *et al*., 1991). The authors developed the SEEA in response to international calls for sustainable development, notably by the World Commission on Environment and Development (WCED, 1987). The objective was to provide a quantifiable definition and database for the new paradigm by introducing environmental concerns into the national accounts.

New scarcities of natural resources, health effects from overloaded sinks for wastes and pollutants, "defensive" mitigation costs, and unaccounted-for non-market activities had driven extended accounting for improved welfare measurement (Merriam, 1968; Nordhaus and Tobin, 1973; Eisner, 1988; Daly and Cobb, 1989; Leipert 1989). A major problem of these welfare measures was their formulation outside the national accounts. Consequently, they suffered from inconsistencies and inaccuracies in their definitions, classifications, and valuations (Bartelmus, 2008).

Opposition to economic growth and its environmentally and socially blind epitome, GDP, drove further efforts to find an alternative to GDP. They included, in particular, a Genuine Progress Indicator (GPI) (Cobb *et al*., 1995). The GPI

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seeks to measure human welfare by adding welfare increasing expenditure and deducting environmental damages and defensive expenditures from personal consumption. Its purpose is indeed to do away with the GDP and the concomitant "polemics of growth" (Cobb *et al.*, 1995, p. 72). The search for alternatives to GDP continued in anticipation of the 2012 Rio+20 Summit. For instance, the Beyond GDP Initiative (European Commission, 2007–2012) looked for indicators that are "more inclusive of environmental and social aspects of progress," and the High Level Meeting on Wellbeing and Happiness at the United Nations (Royal Government of Bhutan, 2012) called for "Gross National Happiness."

Environmentalists criticized the monetization of environmental impacts as the pricing of priceless environmental services. Biophysical indicators, rather than modified economic ones, are their preferred measurement tools. The United Nations (2007) advanced guidelines for indicators of sustainable development, and the International Institute for Sustainable Development (IISD, 2012) hosts a global directory of about 900 indicator initiatives. More compound indices include the Ecological Footprint (Ewing *et al.*, 2010), the Sustainable Development Index (Nováček and Mederly, 2002), and the Environmental Sustainability Index (Yale Center for Environmental Law and Policy and Center for International Earth Science Information Network, 1997–2006). Thermodynamic laws of the conservation and entropy of energy, extended to "matter" (Georgescu-Roegen, 1979), underlie more "balanced" approaches of energy and material flow accounts (Steurer, 1992; Bringezu, 1993; Odum, 1996; Ayres *et al.*, 1998). Physical measures and accounts face, however, problems of comparability and aggregation: they use different units of measurement and questionable weights for environmental impacts, and their definitions and classifications are usually not comparable to those of the worldwide adopted System of National Accounts (SNA) (European Commission *et al.*, 2009).

The SEEA authors aimed, therefore, at an extended accounting system that is internally consistent and compatible with the national accounts. Building on ongoing approaches to natural resource and environmental accounting, notably in Norway (Alfsen *et al.*, 1987) and France (Weber, 1983), they also prepared a draft handbook for submission to the 1992 Earth Summit in Rio de Janeiro. Agenda 21, the Action Plan of the Conference, recommended that ". . . systems of integrated environmental and economic accounting . . . be established in all member States at the earliest date" (United Nations, 1994, para. 8.42). One year after the Summit, the United Nations (1993) published the SEEA handbook as an "interim" technical report, open to further modification and experimentation.

Whether one considers the SEEA-1993 a "landmark" (Smith, 2007) or a "coup" that took national accountants and international organizations by surprise,[1] it was a first systematic and comprehensive response to environmentalist criticisms of GDP and the national accounts. And indeed, the national accountants, who at the time were revising the SNA, rushed a summary of the SEEA into the chapter on satellite accounts. Later, they organized themselves in the so-called

[1]The first (draft) revision of the SEEA-1993, the SEEA-2003, disparaged its predecessor as "a blue-print of what might be done rather than a discussion of what had been done," with an "occasional one-off exercise in a developing country" (United Nations *et al.*, 2003, para. 10.1, 10.2).

London Group (named after its first meeting place) for a critical review of the SEEA handbook. The London Group produced a wealth of often dissenting suggestions and opinions about the objectives, concepts, and methods of the SEEA.

Parallel to these discussions, the United Nations Statistics Division and the United Nations Environment Programme issued an operational manual of integrated environmental and economic accounting (United Nations, 2000), named here SEEA-2000. The manual presented worksheets and software for implementing the SEEA in country projects and discussed policy uses of SEEA indicators. A number of pilot studies applied and tested the proposed concepts and tabulations of the SEEA in industrialized and developing countries (Uno and Bartelmus, 1998).

The London Group decided to revise the SEEA, even if it had to deal with considerable disagreement. Possibly under the influence of a review of environmental accounting by a U.S. panel of economists (Nordhaus and Kokkelenberg, 1999), the resulting draft, the SEEA-2003 (United Nations *et al*., 2003), included welfare (damage/benefit) valuation of environmental degradation. The draft was "noted" by the Statistical Commission of the United Nations at its 2004 session, but never published. In order to obtain consent on a statistical standard, a higher-level UN Committee of Experts in Environmental and Economic Accounting assumed responsibility for the further development of the SEEA. The Committee achieved international agreement by presenting less controversial issues in a "central framework." In 2012 the Statistical Commission adopted the central framework—called here SEEA-2012 (European Commission *et al*., 2012)—as an international standard.

The following comparison of the original SEEA-1993 with the 2012 version is to give a clearer, albeit critical, picture of progress made in green accounting over the last 20 years. Both versions claim to assess the interaction of the natural environment and the economy. The main differences are in the:

- scope and coverage of the environment–economy interaction;
- integration of environmental and economic statistics; and
- compilation and valuation of environmentally adjusted indicators.

Table 1 lists the major issues raised and changed by the revision.

2. Changes in Scope and Coverage

As requested by Agenda 21 of the 1992 Rio Summit, both versions of the SEEA were designed as "satellites" of the SNA (United Nations, 1994, para. 8.41). Satellite accounts modify the concepts, methods, and classifications of the national accounts in separate accounting systems. The purpose is to avoid any changes in the conventional accounts. To maintain comparability with the national accounts, adjustments should be kept to a minimum.

2.1. *Functional Satellite Accounting for Environmental Protection*

Functional (internal) satellites are closest to the original accounts: they regroup and detail a particular subject area, whose stocks and flows are covered in

TABLE 1

SEEA Development and Revision[a]

	SEEA-1993/2000[b]	SEEA-2012 (central framework)
Objectives	Assessment of: • environment–economy interrelationships • sustainability as produced and natural capital maintenance	• Assessment of environment–economy interaction, and of stocks and changes in stocks of environmental assets
Coverage	• Natural assets affected by human activities • Environmental protection • Depletion of natural resources and environmental degradation • *Possible extensions: environmental services, externalization of internal environmental protection, input–output tables*	• Physical assets (with benefits to humanity) and monetary economic assets • Environmental activities, including environmental protection and natural resource management • Depletion of natural resources • *Additional reports: environmental degradation, ecosystem services and other extensions*
Integration	• Linkage of physical and monetary data in hybrid accounts • Comprehensive system of monetary accounts • Numerical presentation for monetary accounts	• Measurement framework for physical–environmental and monetary–economic data, combined in hybrid accounts • Integration of natural resources into the economic accounts • *No common dataset*
Indicators	• Environmentally adjusted net indicators of value added, domestic product and capital formation • Eco-margin (imputed environmental cost) • Environmental protection cost • Wealth in natural resources • *Excluding physical aggregates*	• Selected physical energy and material flow aggregates • Depletion-adjusted economic indicators • Total environmental protection expenditure • Value added generated by the environmental goods and services sector • Wealth in natural resources • *Excluding degradation-adjusted indicators*

Notes: [a]The SEEA versions are not always clear about what they consider accepted convention or debatable alternative. To some extent, this summary reflects, therefore, the author's own interpretation of the intent and character of the revisions.

[b]The SEEA-1993 and the SEEA-2000 are combined, since the latter elaborates on the more practical parts of the original system.

principle in the national accounts. The national accountants revising the SEEA made considerable progress in specifying and reclassifying expenditures on environmental protection and natural resource management in a Classification of Environmental Activities (CEA) of the SEEA-2012. At least for now, the CEA excludes the impacts and reduction of natural hazards [4.24].[2] The SEEA-2012 also provides detailed descriptions of and accounting methods for "other transactions" such as environmental taxes, subsidies, and licenses [4.125], and an "environmental goods and services sector" [4.95]. Further modification of SNA conventions by extending the asset and production boundaries make the SEEA an external satellite.

2.2. *Extensions of the Asset Boundary*

Both SEEA versions expand the SNA asset boundary[3] in their *physical accounts*. The objective is to introduce environmental functions of nature's assets as services to people and the economy. Broad definitions of these services include, besides the supply of natural resources and the absorption of residuals (wastes and pollutants), the regulation of life support and aesthetic and cultural values of the environment (de Groot *et al*., 2002).

The SEEA-1993 includes pragmatically all natural assets in its physical accounts; they are those assets "that are—directly or indirectly, actually or potentially—affected by human activities" [26, 27]. The assets include land, water, air, biota, and related ecosystems. Processes that take place wholly within the natural environment, such as the ambient concentration of pollutants and their disposal by nature [237], are excluded. Their coverage would require a controversial extension of the production boundary [356, 358].

Contrary to the SEEA-1993, the SEEA-2012 uses somewhat ambiguous criteria of use and benefit to determine its physical asset boundary. It defines first the scope of physical assets as environmental components that "may provide resources for use in economic activity" [5.10]; but then it redefines the measurement scope "to include all of the resources that may provide benefits to humanity" [5.14]. Unlike the original SEEA the SEEA-2012 excludes non-material benefits of ecosystem services; they might be dealt with in future experimental ecosystem accounts [2.18, 2.21]. As a consequence, it excludes the qualitative environmental degradation of natural assets altogether [5.88, 91], dealing only with the quantitative availability of natural resources.[4] This omission represents the most significant loss in coverage—as compared to the SEEA-1993—by excluding the absorptive capacities and other functions of nature.

[2]Numbers in brackets refer to paragraphs or sections in the SNA and SEEA versions.

[3]The SNA deals only with economic assets, "which are subject to ownership rights and from which economic benefits may be derived" [2.34]. Natural resources "in the wilderness," which do not deliver economic benefits or for which no ownership rights can be established, are outside the SNA asset boundary.

[4]The SEEA-2012 may come "close" to degradation measurement by recording emissions and nutrient balances; it does stay away, though, from measuring qualitative degradation of natural assets, which it considers a complex issue of detailed asset "characteristics" [5.91–92]. Ecosystem accounts or special handbooks such as the one for water (United Nations, 2012b) might deal with these characteristics [3.188]. Note that the degradation of natural resource deposits is viewed as a "change in the volume" of the resource, rather than a loss in its value [5.93].

The SEEA-1993 maintains in principle the physical asset boundary in the *monetary accounts*. It applies market valuation to natural assets that provide economic benefits, and non-market (maintenance) valuation to environmental sink and other ecosystem services (see Section 5.1). The SEEA-2012 is quite clear about its asset boundary when it comes to monetary valuation: "in monetary terms, the asset boundaries of the SEEA Central Framework and the SNA are the same" [1.46]. The monetary accounts include thus only assets "that have an economic value based on the market valuation principles of the SNA" [5.14]. Monetary economic assets are therefore narrower in scope than those of the physical accounts that seem to include all biophysical assets with benefits to humanity. Accounting only for economic natural resources and their depletion in monetary accounts [5.89] bears the question whether such accounting still deserves the attribute "environmental."

2.3. *Extensions of the Production Boundary*

After extending the asset boundary of the SNA—to let in environmental concerns—all SEEA versions claim to be averse to changing the boundary of production and hence of economic activity. Still, the SEEA-1993 discusses the experimental expansion of the production boundary for consumer durables, ancillary environmental protection, and ecosystem services [334]. In a similar vein, the SEEA-2012 leaves the provision and loss of ecosystem services to experimental ecosystem accounts [1.17, 5.88].

The SNA production boundary excludes all processes that take place in nature without any intervention by economic agents. However, it also excludes the provision of nature's source and sink services, used by households and enterprises, because their use is not the result of a consensual transaction [3.91] between economic agents.[5] The reason is the focus of economic accounting on market transactions and market clearance. On the other hand, such accounting denies nature a value for contributing useful and scarce inputs to the economy. Losses of these inputs from overuse and abuse of nature's services are therefore also ignored. In contrast, both SEEA versions account for scarce natural inputs into and damaging outputs from the economy. They expand the production boundary in this manner, abandoning *de facto* the restrictive national accounts convention for production.

The SEEA-1993 does not show material inputs and outputs in material flow accounts. Rather, it accounts directly for the loss of *scarce* services of nature as depletion and degradation of non-produced natural capital in the asset, production, consumption, and capital accounts [247]. Focusing on monetary accounting, the SEEA-1993 presents physical depletion and emissions as precursors to

[5]The SNA defines its production boundary as comprising activities "under the control and responsibility of an institutional unit that uses inputs of labour, capital and goods and services to produce outputs of goods and services" [6.24]. The "appearance" (e.g., by discovery) and "disappearance" (e.g., from depletion) of natural resources in the economy are not considered production and are recorded as "other changes in volume" in the asset accounts only [12.8]. Note that the costs of natural resource exploration are covered as capital formation in the conventional production accounts [10.90].

depletion and degradation costs. Unlike the SNA, it treats these costs as part of the production accounts because they are the result of economic activities of industries and households.

As in the SNA, both SEEA versions leave extraordinary events of destruction, discovery, uncontrolled natural growth, and replenishment of natural resources outside the production boundary. They record these events as other changes in volume in the asset accounts. Some accountants and economists argue, however, that the discovery of natural resources is capital formation, which should offset their depletion (Landefeld and Howell, 1998; Nordhaus, 2006). The question is if a newly "discovered" or naturally growing resource has indeed been generated by human "intervention" and could therefore be considered as "produced" in greened national accounts.

The SEEA-2012 includes physical natural inputs of ecosystems. It also defines and explains physical depletion of natural resources [5.76], but does not present it as an entry in the monetary flow accounts. Rather, depletion appears like a *deus ex machina* as the adjustment of balancing items in a separate chapter of the "sequence of economic accounts" [6.27, 6.102]. As discussed in Section 4, depletion and degradation costing obtains various environmentally adjusted monetary indicators.

3. Integration: Purpose and Strength

Integrated policies of sustainable growth and development need integrated information. Integration of environmental and economic data into meaningful aggregates is at the heart of environmental–economic accounting. Responding to the international promotion of sustainable development, the SEEA-1993 sought to "assist in identifying strategies of sustainable development" [10]. The SEEA-2012 mentions the policy benefits that SEEA data may provide to a "green economy" and broader sustainable development [1.24]. The two versions differ, however, in their view of integration.

3.1. *Strength of Integration*

The integrative strength of the conventional national accounts stems from connecting accounts and balances in a comprehensive system, in which stocks and flows are measured in the common unit of the market price. Both SEEA versions forego some of this strength when they introduce biophysical data into their frameworks. The use of a common monetary measuring rod can be seen as "strong" integration; by comparison, "weak" integration settles for showing physical data next to monetary data in hybrid accounts.

The SEEA-1993 addresses the immediate interface between environment and economy. It uses the physical accounts as an intermediate step toward the monetary valuation of environmental stocks and flows. To this end, it "combines and translates" physical material, energy, and natural resource accounts "into the language of national accounts" [199]. Illustrative synthetic data are presented only for the monetary accounts [100]. The operational manual of the SEEA (SEEA-2000) compiles physical data in different units of measurement in natural resource

and emission tables [144, 199] for further valuation by monetary unit values. The SEEA-1993/2000 achieves, at least in theory,[6] the highest degree of comprehensive integration of environmental data into the national accounts.

The SEEA-2012 adopts a high degree of *dis*integration by splitting environmental–economic accounts into different parts. Revealingly, it omits the attribute "integrated" in its title, which was still carried by the 2003 version. The first part, the "central framework," covers relatively non-controversial environmental measurement and established economic accounting. This facilitated its adoption by the Statistical Commission of the United Nations as a statistical standard (United Nations, 2012c). Two supplementary parts will not be standards; they will discuss "experimental ecosystem accounts" and "extensions and applications" for further research and analysis [1.18, 1.19].

Within the central framework, "key areas of integration" [6.12–15] refer to SEEA-2012 components, with a focus on "examples of combined physical and monetary presentations" [section 6.5]. The SEEA-2012 considers such hybrid accounting as "one of the most important features" [1.53], showing the "integrated nature of the SEEA" [1.34]. At the same time it admits that "there is no standard form for these presentations or accounts" [6.56]. The central framework also divides the physical accounts into three "subsystems," organized around main units of measurement: material flow accounts (including residuals) are measured in tons, water accounts in cubic meters, and energy accounts in joules [3.11, 3.12]. Full monetary aggregation is achieved only for natural resources and environmental expenditures, for which market prices can be observed or derived (see Section 5). There is no synthetic dataset covering all components of the SEEA-2012 [1.36].

Hybrid accounting represents a form of weak integration as it can only juxtapose physical environmental and monetary economic data in common definitions and classifications. Besides organizing data in a common framework, hybrid accounts can compare time series of different environmental impacts and economic outputs to show success or failure of "dematerializing" parts (sectors) of the economy. Hybrid models of computable general equilibrium and input–output analysis can also be based on hybrid accounts; they introduce standards and thresholds for physical environmental impacts into models of economic performance and growth (Bartelmus, 2008).

3.2. *Statistical Framework or Accounting System?*

The title of the SEEA-2012, "System of Environmental–Economic Accounting—Central Framework," indicates some indecision about the nature of the SEEA: is it a relatively loose framework combining environmental and economic statistics, or an integrative accounting system? The expedient solution is to let the system character prevail where parts of the SNA are just rearranged in the SEEA; this is the case for functional accounts of environmental protection

[6]One of the reviewers pointed out that such strong integration "could never be achieved" in practice. In the view of the author, this should not prevent presenting the "ideal" format of integrated accounts. To paraphrase Samuelson and Nordhaus (1992, p. 295): "vacuum" accounts facilitate the consistent interpretation of monetized environmental impacts in parallel (and hence more flexible) satellites of the SNA. They also facilitate rough exploratory assessments of the overall sustainability of economic performance and growth (e.g., Bartelmus, 2009).

expenditures and asset accounts of raw materials. On the other hand, the characteristics of a statistical framework dominate, where the SEEA-2012 deals with the emission of residuals and biophysical natural amenities that are not traded in markets. For example, one could question the need for a physical accounting approach for residuals when the use of pollutants simply repeats the supply data as in the case of energy residuals and air and water emissions [tables 3.4.1, 3.6.1, 3.6.2].

This treatment blurs the distinction between physical accounts and environment statistics, especially when both show the same or similar stocks and flows. Biophysical environment statistics are probably better equipped to monitor changes in environmental quality and their effects on human health and well-being. The reason is that loose frameworks for organizing statistics do not force data on complex impacts and effects into a rigid system of accounting rules and equations. All in all, the SEEA-2012 appears to consider itself more as a framework for organizing and presenting environmental and economic statistics than a fully integrated system [6.2–4].[7] The online appendix discusses boundary issues between the newly revised Framework for the Development of Environment Statistics (United Nations Statistics Division, 2013) and the SEEA-2012.

4. Accounting Indicators

The system character of the national accounts and their use of a common unit of measurement facilitate aggregation of flow and stock data into sectoral and national indicators of economic performance, income, and wealth. The incorporation of physical environmental data in the SEEA poses a particular challenge for aggregation in integrative accounting.

4.1. *Physical Flow Aggregates*

The SEEA-1993 considers monetary valuation as the most meaningful way of modifying the economic accounts and their indicators; it leaves, therefore, the aggregation of physical data to materials and energy balances outside its framework [206]. The operational manual (SEEA-2000) confirms this decision for practical applications [90]. Time use data of households in production and consumption are another possibility for aggregating human activity. The purpose of such extended and experimental accounting is to measure environmental quality and human well-being [326], notably in a local context.

The SEEA-2012 is aware of the aggregation problem across physical accounts expressed in different units of measurement [3.8]: "A full articulation of all flows is generally most relevant for energy and water" measured, respectively, in joules and cubic meters [3.25]. Still, the SEEA-2012 seeks physical aggregation wherever possible, if only to justify the incorporation of environment statistics in its accounts. Thus, it discusses first the overall input–output identity of total physical supply and use of natural inputs and residuals in terms of material flows [tables 3.2.1, 3.39]. But then, it realizes that the diversity of material flows makes the

[7]A clear description of the purposes and scopes of environment statistics and systemic green accounting might indeed advance the "spirit of collaboration and respect" that seems to be lacking between the two areas [SEEA-2003: 1.108].

overall aggregation problematic [3.224]. The full description of material flow indicators is therefore left to Eurostat's and OECD's work on material flow accounts [3.281]. Gross Energy and Water Inputs and Use are in the end the recommended physical aggregates [3.181–182, 3.220–222].

4.2. *Environmentally Adjusted Economic Indicators*

The SEEA-1993 introduces depletion and degradation directly into the monetary stock and flow accounts as a loss in asset value and cost of production. Deducting these costs from the conventional net indicators of the national accounts obtains Environmentally adjusted (net) Value Added (EVA), its economy-wide total, Environmentally adjusted (net) Domestic Product (EDP), and Environmentally adjusted (net) Capital Formation (ECF). Both depletion and degradation costs are defined as consumption of natural capital. Together with fixed capital consumption they assess the need for reinvestment so as to maintain a nation's capital base and economic productivity [298].

The SEEA-2003 wavers between adjusting the SNA indicators as the "logical culmination of the SEEA" and warning that the extension of SNA aggregates is "not [for] every one" [1.55]. The SEEA-2012 is more radical. It heeds the critique of degradation valuation and costing (see Section 5) and presents only depletion-adjusted indicators. This allows a straightforward, but narrow, definition of environmental cost as a change in the economic value of a natural resource stock resulting from depletion. Deducting these costs from net value added, net domestic product, operating surplus, national income, and net saving obtains the depletion-adjusted indicators [6.27].

One SEEA-2012 indicator, depletion-adjusted net saving, deserves further scrutiny, since it plays a prominent role in a World Bank (2006) measure of saving and sustainability.[8] Adjusted net savings sets aside a "notional" amount from income, whose use for the acquisition of financial or non-financial assets is, however, indeterminate [6.39, 6.40]. Nonetheless, the SEEA-2012 argues that depletion-adjusted savings is to finance the replacement of used-up environmental assets. At the same time it admits that non-renewable resources cannot be replaced. The result of this contradiction is a rather vague justification of the adjustment: "adjusting net saving for depletion can give an indication of the extent to which patterns of income and consumption are in alignment with changes in the overall asset base" [6.38].

Savings is a financial source for spending not only on produced and natural capital (together with capital transfers) but also on financial assets such as cash, bank deposits, and corporate shares. If the objective is sustaining economic performance and growth, adjusting actual investment in non-financial capital for used-up produced and natural capital is more to the point. Positive environmentally adjusted net capital formation (ECF), advanced by the operational manual of

[8]The World Bank indicator of genuine savings is now called adjusted net savings. It is the sum of human capital formation (education) and conventional net saving, adjusted for the depletion and degradation of natural capital. The indicator is both broader (depletion *and* pollution adjusted) and more ambiguous (mixing capital formation and saving) than "depletion-adjusted net saving" of the SEEA-2012.

the SEEA (SEEA-2000), indicates weak sustainability of an economy. It shows that a nation was able to increase the value of its capital base during an accounting period, after taking produced and natural capital consumption into account.

4.3. *Measures of Wealth*

The physical asset accounts of the SEEA-1993 "do not aim at completeness"; they serve to "support" the assessment and valuation of the monetary accounts and their wealth and changes-in-wealth indicators [245]. The SEEA-2012 takes a different view. It defines physical environmental assets broadly as stores of potential benefits to humanity, which need to be preserved for future generations [5.2]. Without saying so, this seems to cater to a strong (non-substitutive) sustainability concept, at least for particular assets within their "specific measurement boundary" [2.103].

All SEEA versions measure overall natural and national wealth in the monetary asset accounts. Where market prices are not available, they estimate market values as the net present value of current and future income streams from using the assets in the production of goods and services.

Broader indicators of "comprehensive" and "inclusive" wealth have found their way into the assessment of sustainable development (World Bank, 2011; UNEP and UNU, 2012). They include, besides economic and natural capital, social and human capital categories. Models of optimality or sustainability of welfare generation determine "shadow prices" of the marginal contribution of the wealth components to economic welfare. Such modeling is not part of accounting but could be included in further "SEEA Extensions and Applications" (SEEA-2012, 1.19).

5. The Valuation Controversy

5.1. *SEEA Valuations*

Economics is about efficient choice and allocation of scarce goods and services. The SNA claims to base its concepts and rules on economic theory and principles [1.64]. From an economic point of view, environmental impacts can be seen as new scarcities of environmental goods and services. The concept of opportunity cost helps identify scarcities, whether revealed in market prices or not. It indicates the forgone next-best alternative that had to be sacrificed when choosing a product or a particular course of action. Opportunity costing reflects also the SNA's approach to valuing capital consumption by determining the cost of hypothetical capital replacement.[9] The concept may help identify scarcity, but the problem is to put a money value on forgone opportunities. It is at this point that disagreement sets in about modifying the national accounts by putting a price on the use and abuse of environmental source and sink functions. The different versions of the SEEA reflect this dissent.

[9]Contrary to the "historic" cost of acquiring a capital good, the cost of capital consumption is indeed indeterminate. The reason is that one does not know if current replacement costs will actually be used for reinvestment, other investment or consumption [SNA: 1.65].

The SEEA-1993 introduces three valuation techniques for the depletion and degradation of natural assets [260]:

- market valuation for the quantitative depletion and qualitative degradation of non-produced natural resources that are "economic" in the SNA sense (see note 3);
- maintenance costing for the loss and degradation of non-economic environmental assets; and
- damage (contingent) valuation of effects of environmental impacts on human health and well-being.

The SNA [ch. 1 H] and both SEEA versions consider utility/welfare-based *damage valuation* as highly controversial because of measurement and modeling issues (cf. Section 5.3). The planned SEEA report on experimental ecosystem accounts might tackle such valuation. This leaves, at least for now, two monetary valuations for applied environmental–economic accounting: market valuation for economic natural assets and asset changes, and maintenance costing for the degradation of non-economic environmental ones.

The SEEA revision makes significant progress in the elaboration of *market valuation* for natural resources that are not traded in markets but obtain a market price after extraction or harvest. The SEEA picks up the SNA recommendation to calculate the net present value (NPV) of rents (returns) gained from using a natural resource over its lifetime [13.24]. Estimating in this manner the stock value of a resource at the beginning and end of an accounting period allows measuring the cost of resource depletion as a reduction in stock value brought about by its physical depletion; it is defined as "disappearance" in the SNA [table 12.2]. Annexes of chapter 5 of the SEEA-2012 explain in detail the NPV approach and the choice of the discount rate [A.5.1, A.5.2].[10] The main difference between the SNA and the SEEA versions is the shift of depletion cost from the SNA asset accounts to the SEEA-1993 production, capital, and income accounts and balances of these accounts in the SEEA-2012. Depletion-adjusted economic indicators are the result.

The SEEA-1993 defines *maintenance cost* as the "costs that are required to prevent or mitigate a deterioration of the natural environment" [257]. Such deterioration impairs in particular the sink function of nature, i.e. the safe disposal of wastes and pollutants discharged in production and consumption processes. Like imputed depletion costs, maintenance costs are hypothetical, since the actual deterioration was not prevented or reduced. In fact, if they were not hypothetical the national accounts would have recorded them as expenditures for environmental protection—together with corresponding changes in relative prices and production and consumption patterns.

The question is where the additional costs should be recorded when they are the result of "externalities." External environmental effects are borne by economic agents who did not cause them. These effects can either cross the market boundary as welfare losses, suffered by people exposed to environmental degradation, or stay

[10]For environmental degradation, market behavior could be simulated by using techniques of cost–benefit analysis such as the increase in travel cost to farther-away recreational areas (Nordhaus and Kokkelenberg, 1999; Nordhaus, 2006). These techniques can evaluate particular programs and projects, but are difficult to apply in economy-wide accounting.

within this boundary when externalities generate production costs for other enterprises (Nordhaus, 2006). Economic efficiency and the precautionary polluter-pays-principle of the Rio Declaration (United Nations, 1994, principles 15 and 16) suggest that in both cases the damage costs should be allocated to those who caused them. Care should be taken to avoid double-counting of costs caused and borne. Note that the costs of natural resource depletion are typically caused and borne by the same actor (the resource owner).

Maintenance costing can be seen as a proxy for assessing the damages of environmental externalities (Baumol and Oates, 1971). They are *potential* expenditures for impact avoidance or mitigation and refer indirectly to society's damage (social cost) evaluation by costing compliance with environmental standards. The hypothetical character of maintenance costing appears to be the reason for the expulsion of environmental degradation by the SEEA-2012. Even the planned research-oriented reports are likely to ignore the cost of environmental degradation: experimental ecosystem accounts would measure ecosystems mostly in physical terms and would attempt valuation only "in so far as it is consistent with market valuation principles"; moreover, they would include "only those issues for which broad consensus has emerged" [1.18].

5.2. *Sustainability Costing of Natural Capital Consumption*

Economic theory and the national accounts cater to sustainability when making an allowance for capital consumption in the production of goods and services. The purpose is to replace used-up produced ("fixed") capital to sustain future production, income, and consumption. Environmental impacts of economic activity represent further threats to the sustainability of economic activity (Bartelmus, 2013).

Both SEEA versions summon multidimensional sustainable development to justify the modification of the national accounts. The inclusion of other capital categories or "pillars" of sustainable development could therefore be the goal of expanded accounting. Near-insurmountable problems of measuring or even conceptualizing the "consumption" of human and social capital explain why both SEEA versions ultimately deal only with produced and natural capital. This is actually quite in line with the 2012 Rio+20 Summit's "green economy" theme (United Nations, 2011). Capital maintenance of produced and non-produced natural capital is however only a necessary pragmatic, but not sufficient, condition for sustaining economic growth.

There is no agreement, though, about the scope and coverage of natural capital. The SEEA versions take the following views:

- The SEEA-1993 accounts for the imputed costs of natural resource depletion and environmental degradation; from a sustainability point of view [54], these costs are the necessary allowance for maintaining the source and sink functions of the natural environment.
- The SEEA-2012 omits environmental degradation and deals only with natural resource depletion; the sustainable use of natural resources is deemed to be the "key driver" of its accounting approach [5.2, 5.3].

Conservative SEEA accountants limit the coverage of nature in the monetary accounts to those raw materials which obtain a price in the market or for which a market price equivalent can be calculated [SEEA-2012, 2.146]. More environment-minded accountants and economists look beyond quantitative changes of natural capital to changes in environmental quality. The idea is to consider natural systems as natural capital when they provide services to the economy, including the absorption of residuals.

One argument for excluding environmental degradation, but including natural resource depletion, is the difference in measuring their costs: market prices are available for assessing depletion, whereas the measurement of degradation needs to resort to maintenance costing. However, discounting the change in stock value (from reduced current and future net returns) does require judgmental choices of the discount rate, and prediction of extraction rates, resource prices, and costs over the estimated lifetime of the resource. Similarly, assessments of degradation cost need to translate past emissions into current change of environmental quality and require estimates of current and future mitigation expenditures. Setting sustainability standards and compliance costs for the emission of pollutants are to facilitate these assessments in practice.

5.3. *Degradation Costing and Modeling*

The harshest critique of maintenance costing of environmental degradation refers to changes in production and consumption patterns by a presumed internalization of externalities into the budgets of economic agents. Such behavioral change should not be part of *ex-post* accounting, as it is a matter of modeling. This conclusion is correct, but the assumption that environmental degradation costing requires behavioral (optimizing?) modeling [SEEA-2003, 10.171] is not.

When budgeted, imputed maintenance cost is turned into internalized cost, which will indeed affect output and income. In theory, internalizing the damage value of unaccounted-for environmental impacts could re-establish allocative efficiency for welfare maximization. A recent environmental accounting study for air pollution in the United States (Muller *et al*., 2011) applied thus marginal damage valuation. Ignoring the structural change of the economy brought about by cost internalization, the authors deny seeking optimization. But damage valuation does require the modeling of the full physical emission–concentration–exposure chain for the flow of pollutants from emissions to people; it applies also highly uncertain mortality and morbidity risk assessment and willingness to pay for risk reduction.

One should distinguish, however, between descriptive modeling for estimating actual physical impacts and their cost [SEEA-2012, 5.52, 5.64, 5.97] and prescriptive or explanatory modeling of changes in economic behavior. The former can find its way into *ex-post* accounting for the imputation of opportunity costs that are not directly observable. The latter is a matter of predicting what would happen to the economy if economic agents are confronted by governmental regulations or market instruments such as eco-taxes and tradable pollution permits; it is an analytical use of accounting data, but not a recording of past environmental impacts.

However assumptive the maintenance costing of the SEEA-1993 may be, the purpose is not to calculate an optimal (marginal) avoidance or restoration price.

Rather, maintenance costing is to reflect the actual (average) opportunity cost of having ignored environmental deterioration during a past accounting period. From a sustainability point of view, the opportunity costs are the expenses that would have avoided or reduced (to desirable standards) the decline in nature's source and sink services. Maintenance costing has the advantage of avoiding welfare/damage optimization and valuation. It provides the monetary weights for the aggregation of actual impacts caused during the accounting period.

As pointed out in Section 5.1, maintenance costs are indeed hypothetical. But so are the values of depletion and fixed capital consumption, whose ultimate use for (re)investment or final consumption is not known. On the other hand, economic agents might already have accounted for environmental degradation by reserving funds for expected governmental intervention or out of a sense of corporate responsibility. In this case, the degradation-adjusted national accounts would simply correct the omission of an internalized environmental cost. There is however no clear evidence of the significance of such unrecorded cost internalization.

Descriptive accounting and modeling of hypothetical environmental depletion and degradation cost is an argument not against but *for* such accounting: estimates of the value of depletion and environmental externalities generated during an accounting period provide the necessary information for a rational setting of economic (market) instruments. Their use should lead the economy closer to efficiency and sustainability.

6. Concluding Remarks

The common goal of all SEEA versions is measuring the interaction of economy and environment. The reason is that the impacts of this interaction threaten the sustainability of economic activity. The national accountants ignored these threats until the international debate of sustainable development made them extend the economic accounts into the field of environment. A satellite system for integrated environmental and economic accounting, the SEEA-1993, was the result.

Pilot studies revealed serious data gaps (Uno and Bartelmus, 1998). Filling the gaps requires assumptive estimates and valuations, notably for the non-market sink services of the environment. The national accountants responsible for revising the SEEA are however ambivalent about incorporating environmental degradation. On the one hand, they seek to take in the relatively new field of environment statistics. On the other hand, they recoil from fully integrating environmental data in a monetary, and hence truly integrative, system of extended national accounts. The result is the central framework of the SEEA-2012, which includes biophysical statistics but excludes environmental degradation. Hybrid—physical–monetary—accounts, which show discharges of wastes and pollutants next to economic indicators, are to compensate for this omission.

The expulsion of environmental degradation from environmental–economic accounting sends the wrong signal to policy makers and national accountants. It sacrifices the need for a comprehensive assessment of the environment–economy interaction to statistical rigor, even when a satellite of the established accounts could be more open to experimentation and analysis. Such a satellite system does

not have to be a statistical standard, which requires difficult-to-achieve agreement among data users and producers.[11] Rather, it could offer accounting options, from which national accountants and decision makers can choose according to their priorities and capacities. The previous versions of the SEEA presented a good deal of these options.

Perhaps the greatest advance made by the SEEA-2012 is the elaboration of natural resource accounting in physical and monetary terms. In particular, the SEEA-2012 offers clear definitions and valuations of natural resource depletion [sections 5.1, A5.1]. In fact, one could go even further. There are good reasons for introducing depletion costs directly into the conventional accounts, rather than placing them into a satellite. The arguments of the SNA for excluding depletion cost from the production and income accounts are tenuous: depletion is deemed to lack the characteristics of a "transaction," since it is not carried out by mutual consent between economic agents [2.22, 2.23]. Depletion does create, however, a cost of capital loss, which affects the generation of income. Moreover, consent on transactions could be construed between the owners (including government) and users of natural resources. The time might have come, therefore, to account for resource depletion in the production, capital, and income accounts of the SNA.

Describing the use and usefulness of the SEEA in policy and more managerial decision-making could go a long way to revitalize interest in the SEEA. Interest seems to have waned. Since featuring the original SEEA in the 1992 Rio Summit, the follow-up conferences did not mention integrated accounting. The 2002 Summit focused on lists of difficult-to-aggregate-and-compare indicators (United Nations, 2004, para. 130, 131), and the 2012 summit called for "broader measures of progress to complement gross domestic product" (United Nations 2012a, para. 38). Nonetheless, the SEEA-2012 relegates the discussion of SEEA applications (included by the SEEA-2000 and -2003) to a future report on "SEEA Extensions and Applications" [1.19]. Much of the flavor and explanatory power of the previous versions is sacrificed for a lean technical description of accounting methods.

The next revision of the SEEA should not only include environmental degradation; it should also explain the capabilities and limits of the greened accounts in informing and monitoring sustainability policies.

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[11]The Statistical Commission (United Nations, 2012c, decision 43/105) seems actually to have misgivings about making the SEEA a standard, qualifying its adoption as "initial" and "subject to further revision, acknowledging that further improvements on measurement are necessary on specific issues."

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix: Relationships Between FDES, SEEA and SNA
Figure A.1: Contributions of FDES and SNA to the SEEA-2012