Issue paper on

Natural capital

Prepared for the 30th Meeting of the London Group on Environmental Accounting by:

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Questions to the London Group:

- Given the issues regarding the inclusion of natural capital in the SNA raised in this paper, should the SEEA (CF) react to the inclusion of natural capital in the SNA?
    - If yes, how could a unifying definition and an alignment of scope and methodology look like?
    - If no, should SEEA CF clarify its asset categories (environmental and ecosystem)
- Do you agree with the implications and issues for assessing sustainability raised in this paper? How can the SEEA (CF) address these issues?

I. Introduction/Motivation

The concept of natural capital accounting (according to SEEA) implies that "natural capital should be recognised as an asset that must be maintained and managed, and its contributions (services) be better integrated into commonly used frameworks like the System of National Accounts". A closely related perspective is that in order to broaden the measurement of well-being beyond economic performance, a comprehensive wealth approach should capture not only economic capital, but also social and natural capital. The SNA 2025 states that "the sustainability of past developments is implied if the level of [comprehensive] wealth in real terms is non-declining" (SNA 2025, 35.105) – implying a weak sustainability argument – and that the capitals approach can support other ("stronger") sustainability concepts.

While the term natural capital has previously not been defined and used in statistical accounting frameworks such as the SNA 2008, the SEEA CF 2012 or the SEEA EA 2021, it is explicitly introduced in the current SNA 2025 Revision as a new asset category. This development together with the widespread but fuzzy use of the natural capital concept[1] warrants a closer view on potential issues and implications for the System of Environmental-Economic Accounting.

The paper first describes the conceptual background for natural capital accounting, its role in economic theories and in different sustainability concepts, highlighting the motivation behind and stark critique of natural capital accounting. It then discusses and addresses the following issues.

A. Defining natural capital: clarity and transparency for users: Even within the realm of official statistics, various frameworks include references, definitions and measurement scopes for nature, natural capital, natural resources and environmental assets. These may overlap, complement each other or describe distinct sets. We present a comparison across statistical frameworks and deduce a potential unifying interpretation of nature understood as capital and its subgroups (*natural capital as an umbrella term*). The paper also highlights related issues regarding potential double counting, potential misinterpretations and conceptual contradictions.

B. Implications of the 2025 SNA revision for the SEEA CF Update

After the revision is before the update.[2] In its list of potential issues for the SEEA CF update the SEEA CF Technical Committee includes the following item regarding the inclusion of natural capital in the SNA 2025. It calls for a consideration of implications for the SEEA CF, a need for a harmonised asset classification, overlaps in terminology and an impact assessment.

> *In the 2025 SNA revision, several issues have been addressed in the area of natural capital and the environment, and the updated SEEA CF must consider the implications.*

[1] Reflecting a wide range of definitions and sometimes monetary and/or physical assets.
[2] Free after Sepp Herberger ("After the game is before the game").

> *In addition, there is a need to understand the implications of changes to the asset classification of the 2025 SNA, as there is a need for a harmonized asset classification for the SNA/SEEA from a SEEA perspective, i.e. the inclusion of natural resources / ecosystems / renewable energy resources etc. In addition, there may be overlaps in terminology between the SEEA CF and 2025 SNA which need to be clarified.*
>
> *To ensure consistency with the SNA it should be investigated if the changes in the 2025 SNA have an impact on the SEEA. First an overall impact assessment of the proposed changes will be done. Based on this assessment, changes to the SEEA may be proposed.*

The present paper is a starting point to address these issues. However, the issue is not merely one of whether and how to align definitions, scope and methodology. Accounting for certain aspects of nature as capital has further implications on how sustainability is assessed ex-post and environmental policies are informed. It should be discussed, if and how these latter issues ought to be addressed in the SEEA CF.

C. What and how to account for natural capital matters for sustainability analysis

There are different definitions of sustainability and different concepts of how to assess sustainability, e.g. the range between weak and strong sustainability. Defining and measuring natural capital in monetary terms as proposed in the 2025 SNA Revision implies a weak sustainability perspective with a focus on the economic benefits derived from that natural capital. The SEEA should provide a more comprehensive view on sustainability that addresses challenges arising from the application of the qualification of “capital” to nature as well as offer tools for a broader set of sustainability concepts.

D. Well-defined boundaries are needed for valuation

Whether a necessary relationship between valuation and the application of the notion of capital to nature and whether and how to value natural capital are important issues of their own. However, if one chooses to do so, defining the scope is crucial.

> *The core of the challenge is the need for nonmarket valuation studies that align with deliberative accounting boundaries, such as current SNA boundaries or other extended boundaries a statistical office may choose to adopt [...]* (Fenichel & Obst, 2024)

A point in question is how far “deliberative” one can go in setting the accounting boundaries, without disrupting the basic principles on which accounting is built, such as it being a statistical framework based on observation and respecting core concepts such as the “third party principle”.

II. Conceptual background

A. Why and how: Defining and Measuring Nature as Capital

There is a long history of treating nature and natural resources as capital, starting at least as far back as when John Muir and Gifford Pinchot debated about sheeps’ grazing in protected forest areas. More recent cases are documented in Scott (1973) and Gaffney (2008). By some authors natural capital was included in wealth accounts and treated much like other forms of capital as a source of income flows and a (partially) non-produced factor of production and economists soon included natural capital in their conceptual frameworks (e.g.

Weitzman 1976). Some others, further from the mainstream, vigorously refused this line of development requiring the “pricing” of nature, even if contributing substantially to the success of the “natural capital” expression, which they used as a metaphor (Schumacher, 1973).

As one of society’s capitals, measures for natural capital are required to understand sustainability, if the analysis is based on measuring welfare (or wealth) over time using a capital approach (e.g. World Bank, UNEP). As Radermacher and Steurer (2015) describe, a narrow capital approach is based on monetizing and aggregating different capitals (including natural capital). Depending on assumptions about substitutability, variations from weak to strong sustainability (e.g. critical natural capital approach) can be implemented. In practice, however, this approach is marked by significant challenges.

> *Yet, despite strong theoretical support and interdisciplinary buy-in to the idea of natural capital, the measurement and incorporation in decision-making of the value of natural capital has lagged for many critical stocks […]* (Fenichel & Abbott 2014).

> *There is a massive lack of knowledge about the state and functioning of the phenomena at stake in physical terms […]. The valuation of these phenomena is both conceptually and practically very difficult.* (Radermacher & Steurer 2015)

As emerges from these sketchy reminders, the concept of Natural Capital is very much connected to that of grasping the *value* of its contributions to human welfare, to the conceptualisation of the latter as *income* and to measurability of the “services” that this capital provides in monetary (i.e. exchange value) terms (pricing). However, there is no necessary link between the idea that nature is capital and monetary valuation. For instance E.F. Schumacher, who is often (wrongly: see Missemer 2017) credited to be the first user of the “natural capital” expression, denied radically the legitimacy of such valuation:

> *In the market, for practical reasons, countless qualitative distinctions that are of vital importance to man and society are suppressed; they are not allowed to emerge. Thus, the realm of quantity celebrates its greatest triumphs in the 'Market'. Everything is equated to everything else. Equating things means giving them a price and thus making them exchangeable. To the extent that economic thought is based on the market, it removes the sacredness from life, because there can be nothing sacred in something that has a price. It is therefore not surprising that economic thought pervades the entire society. Even simple non-economic values like beauty, health, or cleanliness can only survive if they prove to be "economic."*
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> *To fit non-economic values into the framework of economic calculation, economists use the method of cost/benefit analysis. It is generally believed that this is an enlightened and progressive development, as it represents at least an attempt to take into account costs and benefits that would otherwise be ignored altogether. In reality, however, it is a procedure by which the highest is reduced to the level of the lowest and a price is given to the priceless. It can therefore never serve to clarify the situation and lead to an enlightened decision. All that can be done is to lead to self-deception or to deceive others; in fact, undertaking the measurement of the immeasurable is absurd and constitutes only an elaborate method to move from preconceived notions to obvious conclusions; all that needs to be done to achieve the desired results is to assign appropriate values to the immeasurable costs and benefits. The logical absurdity, however, is not the greatest flaw of the endeavour: what is worse, and destructive to civilization, is the claim that everything has a price or, in other words, that money is the highest of all values.”* (OpenL’s translation from the Italian edition, checked by Aldo Femia).

As a proof of this non-necessity of the link with monetary valuation, we witness examples of Natural Capital Accounting from all over the world, that do not see monetisation as a priority in Natural Capital Accounting. One of such examples is given by South Africa’s NCA:

> *Using accounts to quantify natural capital and its benefits is always done in biophysical terms, such as the extent of an ecosystem remaining in its natural condition, amount of water produced by a catchment, the volume of fish harvested from the marine environment, and the number of people visiting protected areas. This may, where it is useful and appropriate, be translated into monetary values. Yet [...] natural capital accounting does not mean that we have to reduce natural resources and ecosystems to rands and cents.*
>
> *[...] These accounts are compiled in biophysical terms. Where useful and appropriate, this may be translated into monetary values, but often that is not necessary. There are many examples of issues that are important to society that are measured in non-monetary terms, like literacy rates, matric pass rates, infant mortality, unemployment levels, life expectancy and other health and education outcomes. The same is true for natural resources and ecosystems – their importance and value to society can be captured in a range of statistics and indicators, many of which are non-monetary.*

Finally, it is also not a logical necessity that the "connection with monetary values", where done, should consist in a "translation" of physical values into monetary ones, i.e. respond to the valuation/pricing logic that national accounting applies to produced goods and services, rather than to a satellite accounting SEEA CF-type logic where monetary values that depend or are elsehow connected to physical flows from the environment are identified, isolated and represented in *ad hoc* tables.

The concept of natural capital and accounting

As we have seen, the concept of natural capital first appeared in environmental economics. On the other hand, the concept of capital has been used since Antiquity in the organisation of market life. When modern accounting was created, in particular with Luca Pacioli's seminal work, it began to crystallise particular conceptions of 'capital'.

The word "capital" comes from the latin word "capitalis", an adjective derived from the substantive "caput" (head). The reference, as for the economic meaning of the term, is to cattle herds, whose primary measure is and was the number of heads (in Italian: "capi") they contain. "Capital" therefore originally concerns a physical asset under human control, which of course comes - as everything - from nature but is no longer nature as property rights are enforced on it and it is economically used, and cared for by an owner.

Rambaud (2023) summarises the history of the use of this term in accounting. Initially, the term capital came from the Latin expressions *capitalis pars debiti* (capital or principal part of a debt) (Böhm-Bawerk, 1890) and *caput pecuniae* ('head', principal part of the money lent) (Cange et al., 2020; Nobes, 2015; Sweeney, 1933; Tuttle, 1903). Capital corresponded to the part of the loan that had to be repaid in full and had to be kept intact, at least for a certain period, as opposed to interest, which could be spent. Capital was therefore not a productive thing in itself, generating a return or profit, but something to be preserved. This view of capital persists to this day in accounting and business practice, but a second view emerged at the turn of the Renaissance.

For cultural and cosmological reasons, corresponding to the beginning of Modernity (Latour, etc.), capital became impregnated with the Object-Subject distinction and became synonymous with everything productive in 'work and industry' (Wood, 2002). It thus extends to the notion of profit as the effect of a cause (the principal share). Two perspectives have emerged from this. The first is called materialist, and considers that capital is a set of physical objects with an intrinsic productivity that is not, however, easy to link to profit. The

value of capital is calculated in terms of its entry value, or market value at a given point in time. The second perspective is called 'fundist' and considers that capital is a quantity of money that generates profit. Capital is valued as the flow of future profits (possibly discounted). Table 1 summarises these different views of capital.

	(Modern) Capitalist Capital		**'Capital' as the principal of a monetary debt (Classical financial accounting)**
	Materialist Perspective	**Fundist Perspective**	
	Capital as a *debit concept*		Capital as a *credit concept*
'Capital account' financial accounting	The 'capital (Equity) account' is a representation of Capital in its Capitalist sense. 'Capital account' is a *receptacle* of values generated by assets/Objects, for the central Subjects of business (owners/shareholders) after deduction of the debt owed to other Subjects (outside the business).		The 'capital account' is a liability account like any other. Recognition of the contribution in capital by owners/shareholders, and the need to guarantee its preservation for them.
Capital and balance sheet	Capital (Equity) is defined as net assets.		The liability side of the balance sheet structures the different capital contributions and, therefore, the different obligations to guarantee that capital will be preserved at term.
Capital	Capital is the representation of the Power of the central Subjects of business (owners/shareholders). Capital is dependent on the activity of the firm.		Capital has an existence of its own (as money), defined outside of the business. Capital is independent from the activity of the firm.
Evaluation of capital	Aggregation of the market (entry values) values of each asset.	Present value of the combination of the assets.	Nominal value of money brought to business and to be repaid.
Capital maintenance	Maintenance as asset management.		Preservation of the independent existence of capital (money)
Double entry principle	Inventory/reporting for Capital-as-receptacle. Dichotomy between Assets/Objects and 'Capital and Liabilities'/Subjects.		Dynamic recording of flows of capital, recording in particular its uses and consumption.
Matter of concerns	Capital (assets) management and optimization.		Capital protection/ preservation.

Table 1: Capital(s) and accounting systems (source : Rambaud 2023)

These conceptions of capital in classical and modern accounting can be linked to that of natural capital. Environmental economics, adopting a modern perspective on capital, has produced materialist and fundist concepts of natural capital, which can be found in the SEEA, but also in initiatives such as the International Sustainability Standards Board (ISSB - heir to the fundist vision supported by the International Financial Reporting Standards - IFRS), the Natural Capital Coalition, and so on. At the same time, there is a growing body of research that proposes to anchor the classical notion of capital as debt, and therefore as an object of conservation concern in its own right. Drawing on environmental ethics, it proposes a vision that is genuinely ecological. It would allow the environment to be represented in management tools built from a relational perspective. It is thus possible to count and take into account all existing ecological entities (and those that society wishes to preserve), without interposing a filter that only lets through those that are significantly 'productive' for human well-being. This is in line with the recommendations of the IPBES report on values (2022), which encourages us to move away from, or at least complement, a purely instrumental vision of the environment and the corresponding tools.

The concept of natural capital and economic theories

In traditional economic theory, specifically neoclassical theory, production is represented through a mathematical function that has labour and capital as its arguments. The most obvious way to include nature without changing the theoretical framework, is to add the "natural capital" production factor to this representation. The conceptual category of capital specific to that theory is simply applied to the use of nature, and does not require special care when the stream of services from nature is extended from traditional, exhaustible, natural resources to ecosystem services (and even to immaterial entities such as radio spectra or renewable energy sources). Indeed, in the neoclassical production function, the natural capital input argument represents the flow of the services of natural capital used in production, whose value and contribution are measured as any other current value, i.e. by their price. The postulated symmetry between the various forms of capital makes the theory mathematically neat and appealing. Neoclassical economic theory is the same on which the so-called "welfare theory" is based. Within this framework, the prevailing policy idea is that in order to achieve optimal results (in terms of welfare) it is necessary to "internalise" the costs that do not pass through the market, referred to as externalities. As a result, there would be a degree of protection of nature that is defined as optimal not based on ecological criteria of balance, such as stability over time and its associated resilience, but rather based on the preferences of individuals as they manifest in markets. Therefore, there is no a priori reason why economic optimality in the use of resources should imply the maintenance of ecosystemic balances. To achieve conservation, in this theoretical framing it is necessary to hypothesise not only that markets are complete and competitive, and that all economic agents are perfectly informed and have infinite computational capacity, but also that those who live and decide now are (paternalistically) altruistic towards future generations. The same internalisation can be achieved, in the imperfect markets and people world we live in, with corrective interventions of a benevolent economic policy authority, whose range of action goes, remaining in the economic instruments realm (i.e. setting aside strategies based on command and control as well as on awareness raising and on promotion of pro-conservation culture and ethical values), from direct intervention on price components such as taxes and subsidies to the *ex nihilo* creation of new markets, in which willingness to pay for protection and willingness to accept the "collateral" costs of production can be freely

traded. It should also not be forgotten that the willingness of different individuals depends on their spending capacity, while the subjective appreciation of nature takes on secondary importance: what matters is the effective demand, that is, the demand of those who have the means to pay. So, in order to have socially acceptable (equitable), and not just efficient (Pareto-optimal) outcomes, also the initial distribution of wealth must be “right”.

On the statistical side of this theoretical approach, the reference to the Hicksian definition of income (“a man’s income [i]s the maximum value which he can consume during a week, and still expect to be as well off at the end of period as he was at the beginning”), strictly related to that of wealth (“well off”), i.e. - after all wealth has been designed as such - to that of capital, and the awareness of the limitations of GDP as a measure of income, have given rise to a wide range of approaches, many of which are based on the idea of ‘correcting’ the calculation of GDP (e.g. to determine the “genuine” income) and of wealth, by including the monetary expression of values (and costs), amongst which are the ecological ones, not considered in the usual aggregates of national accounts.

Ecological economics, on the other hand, following Schumacher and with the lessons of - among others - K. W. Kapp (1950), H. Simon (1955), K. Boulding (1968, 1970, 1978) and N. Georgescu-Roegen (1975) in mind, placed the pluralism of values amongst its conceptual foundations (Martinez-Alier et al. 1998) and stated that it is not possible to trace back the erosion of the natural, nonproduced physical basis of production (and of life) to a single and all-encompassing measure of capital and income, let alone a monetary one. Neoclassical environmental economics is criticised for its lack of consideration of the laws of thermodynamics and the absence of the factor of time in economic models, understood in a historical sense rather than as a mere dynamic variable. Moreover, the mechanistic conception of the human being is considered a-scientific. In fact, this reduces humans to mere and fully rational economic agents, that is, self-interested and always capable of ordering the options presented to them according to predetermined preferences, of establishing terms of trade for everything and of finding the optimal transaction, impermeable to experience, to higher ethical values (that place what is most essential outside the dimension of utility and market exchange), to sacrality and wonder (Carson, 1954). As for the policy implications, the push of neoclassical economic policy towards the creation of markets for new forms of capital are called into question by the the oligopolistic structures of markets, the imperfection of information, the limited individual calculation capacity, the persuasive power of advertising, and, nowadays, also by the increasing control exerted by extractive data capitalism and the tendency to indistinguishability between what is true, real, actual, and what is fake, distorted, or even entirely invented, yet still plausible, credible, and accredited as truthful.

Although not necessarily linked to the tradition of ecological economics, numerous initiatives, more and less recent, adopt a substantially multidimensional vision (de Groot et al. 2006, Kosoy and Corbera 2010, Farley 2012, Kumar 2012) and go in the direction of expanding the sets of indicators for measuring wellbeing and sustainability. Amongst the most significant ones, the Stiglitz-Sen-Fitoussi Report (Stiglitz et al. 2010) and the Sustainable Development Goals (SDGs), adopted by the United Nations in 2015.

Finally, there is one author, founder of a very influential school of thought, who is seldom mentioned in this context, but would surely have much to say, having dedicated most of his

scientific efforts to understanding the essence of capital, as far as to entitle “Capital” his major work. The definition Marx (1887) gave to this word is quite restrictive, going in a direction totally opposite to the neoclassical one, and cannot be separated (as for all other schools of thought) from the conception (theory) of value. As wikipedia puts it:

> *[E]conomic value is a social attribution, which expresses a social relation between people that is specific to certain historical conditions. Inanimate objects can only feature in value relations as tokens of prior human effort, since they are not social beings. Thus, it is not the machine with which new outputs are produced that itself adds value to those outputs, but rather the people operating the machine who permit its value to be conserved and who operate the transfer of part of its value to the new outputs.*

Clearly this conception of capital cannot be extended to Nature. The aim of capitalist production is having capital itself grow and accumulate. Capital does not identify a collection of objects as much as a social relationship, based on private property of the means of production and on wage labour.

Even if not being subject to characterisation as capital, Nature plays an important role in the marxist theory. The initial formation of capital is connected to the detachment from nature of the workers, starting with the so-called “primitive accumulation”, which is nothing else than the institutionalisation of the historical enclosures movement, i.e. the appropriation of nature (land) for economic purposes and the making of the working class by expulsion from the land (Thompson, 1963). The spreading and deepening through history of this specific form of relationship between humans and nature is just another side of the development of productive forces - i.e. to the imposition of the human domain on Nature in terms of power and knowledge (for which Marx had a sense of admiration because of the potential of liberation of humankind it entails) - radiating from the centre to the periphery of the capitalist system. The importance of the colonisation of Nature both as an expansion domain for capitalism and as a supplier of new resources was emphasised more than by anyone else by Rosa Luxembourg, who wrote about the permanent character of primitive accumulation. In their idea that there is a correspondence between the fundamental, material, structure of (socioeconomic) relationships and the cultural and institutional superstructures shaped by the dominant class and its interests, marxist ecological economists argue that the “capitalisation of nature” movement is a natural evolution in the subsumption of nature to capital (Spash and Haché, 2021). Their opposition to the idea that the multiplicity of the use values of Nature should be reduced to monetary measures is parallel to:

- the political aversion towards the idea that everything should be appropriated (and then freely marketed) and
- the scientific aversion to the concept that the Pareto-optimality of market allocation may achieve something else than an “optimal” path of Nature destruction, as long as the initial allocation of resources is skewed in favour of those whose interest is in capital accumulation and Nature’s productive use - no matter how “capital” is defined in statistical terms and whether it comprises unappropriated Nature or not.

B. Discussion of sustainability concepts

<u>Natural capital between weak and strong sustainability</u>

In general, the dominant economic theory is confident in the market system and in the ability of prices to signal the scarcity of resources. An increase in oil prices, for example, would

lead to technological advancements capable of both using oil more efficiently and replacing it with alternative fuels (natural gas, for instance), and also stimulate research and innovation in new energy generation technologies, such as nuclear fusion or new renewable sources. The virtuous circle between changes in relative prices and technological progress thus triggers an increase in efficiency that, for economists, would solve the problem of resource scarcity.

Traditional economic theory has believed, through this path, that it could overlook the issue of the material basis of economic processes and thus support the possibility of unlimited economic growth, provided that the effects of pollution can be mitigated through technological innovation. The theme of the relevance of resources has been addressed in several academic articles from a special issue of the Review of Economic Studies, among which the most relevant are those by Dasgupta and Heal (1974), Solow (1974), and Stiglitz (1974), the latter two Nobel Prize winners in 1987 and 2001, respectively. In these works, a series of neoclassical growth models with exogenous technical progress are developed in which, along with capital and labour, the production function also includes a natural (depletable) resource and in which utility depends only on consumption. The outcomes crucially depend on the elasticity of substitution (the ease with which the input of one factor of production can be reduced while increasing the other, keeping output unchanged) between the services of produced capital and the resource. For an elasticity value greater than one, production is possible even with increasingly smaller quantities of resources, until reaching practically zero quantities. For elasticity values less than or equal to one, these models allow for constant utility over time (or even its growth) in the presence of sufficiently strong technical progress that enables progressively doing with fewer resources. In conclusion, when the degree of substitutability between artificial capital and natural capital in production is sufficiently high, consumption can be maintained or grow over time if the reduction of the stock of exhaustible resources is compensated by the increase of the stock of artificial capital.

The issue of the limits to growth is thus resolved in the substitutability between factors. This is the essence of the weak sustainability approach. This has been clearly highlighted in another well-known contribution, that of Hartwick (1977), in which the possibility of maintaining consumption over time is analytically demonstrated if all income derived from the sale of natural resources is invested in produced capital to compensate for the decline of non-renewable resource stocks. In other words, the rents generated from the extraction of non-renewable resources must be saved and reinvested in artificial capital. These arguments can also be easily inferred in formal terms by stating that the aggregate consumption of the entire society (C) is equal to the product (Y) - produced with human-built capital (K), labour (L), and non-renewable resources (R) - from which depreciation (that is, what must be employed to replace the capital that deteriorates) and new investments (which increase artificial capital), as in the subsequent equation.

$$C = Y\big(K(t); L(t); R(t)\big) - \delta K - \frac{dK}{dt}$$

A reduction in resources leads to a reduction in output unless it is replaced by an increase in capital, the increase of which, however, will raise the need for depreciation expenditure. For

this reason, it is essential to assume that small increases in capital are sufficient to offset the reduction in resources. Essentially, Hartwick demonstrates that a constant flow of consumption over time can be ensured despite the progressive reduction of R.

However, it soon became clear how traditional growth theory oversimplified the relationship between economy and nature, treating the latter as merely a repository of resources for production. As was also recognized in a publication by economists not far from the traditional approach and which achieved great success (Pearce et al. 1989), nature performs vital functions for human beings and for life in general, and economic growth requires not only the replacement of resources but also the mitigation of the damage caused to production by a severely compromised environment. This amounts, if the “weak sustainability” logic is applied also to this mitigation need, to introducing a new term in the same equation as above. This is a major example of how, over the years, mainstream economic theory has gradually expanded its view of the relationship between the environment and the economy, and nevertheless it has continued to favour a mono-dimensional perspective where different forms of “capital” basically play the same role (input to production) and can in principle be compensated for one another (weak sustainability). Such an approach “naturally” requires that a monetary value be assigned to natural capital, not just for the inclusion in the equations, but for the basic comparability of different capitals that characterises it. The measurement of heterogeneous phenomena using the same unit of measurement has allowed for the operationalization of substitutability à la Hicks-Hartwick-Solow. In particular, Pearce and Atkinson (1995) propose to judge a nation as sustainable if

$$S > \Delta K/\Delta t + \Delta N/\Delta t\,,$$

where S are the savings, while the other two terms are respectively the depreciation rates over a certain period of time for artificial capital and natural capital.

This kind of view on sustainability has been the subject of strong criticism from a new approach to environmental economics, that of ecological economics, which, after a period of gestation, developed from the second half of the 1980s. This approach, emphasising the interdependence between ecosystems and economies, recognizes that the processes governing nature and human affairs unfold over different spatial-temporal scales. It is in this light that ecological economics opposes the idea of weak sustainability, asserting not only that natural resources are not easily substitutable by increases in artificial capital, but that sustainability, due to the complexity of interdependencies and the different functions of nature, requires the maintenance of a certain level of natural capital, considered per se, i.e. with no necessary reference to its monetised value.

Regarding the issue of the substitutability of resources, Herman Daly, one of the founders of the ecological economics school, is among those most committed to advocating for a "strong" vision of sustainability. Such a vision not only highlights how renewable resources cannot be exploited at a rate faster than their physical regeneration but also that the rate of pollution and waste generation cannot exceed the rate at which natural systems can absorb, recycle, or otherwise neutralise them. Natural capital is thus interpreted as the capacity of ecosystems to produce not only flows of natural resources but also a variety of ecosystem services; it thus becomes essential to maintain it at appropriate levels, which defines the

"strong" version of sustainability. Natural capital is seen as a set of natural elements that meet fundamental needs and must therefore remain above a certain "critical" level.

III. Definitions of Natural Capital

There are various definitions of natural capital and related terms like natural assets, natural resources, environmental assets and ecosystem assets used in different statistical / accounting systems. Earlier definitions focused on natural capital as input for economic production:

> *Natural capital [are] natural assets in their role of providing natural resource inputs and environmental services for economic production.* (United Nations 1997)

Over the last 20 years, these definitions have made way for more economic views of natural capital as a stream of current and future flows of benefits to people.

> *Natural capital refers to the stock of renewable and nonrenewable natural resources that are used by economic units (i.e., industries, households, and government), including flows of nonrenewable resources like energy and minerals as well as ecosystem services.* (United Nations 2020)

This shift in emphasis from the actual and current physical phenomenology of “natural assets” - even if seen in their role of serving production - to the projected stream of benefit flows tightens the bond with the valuation/pricing perspective, as it perfectly corresponds to the way natural capital is measured in monetary terms under this perspective (SEEA CF ch. 5; SEEA EA ch.10; SNA 2025 revision on renewable energy sources).

A. Statistical (Accounting) Frameworks:

1. <u>System of Environmental-Economic Accounts Central Framework (2012 SEEA CF)</u>

The SEEA Central Framework (SEEA CF) is a conceptual framework for compiling integrated statistics on the interaction between the environment and the economy, and on the stocks and changes in stocks of environmental assets. The framework does not refer explicitly to natural capital (in fact refraining from using the term entirely), but instead to environmental assets, which are defined as follows:

> *Environmental assets are the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity.* (SEEA CF, 2.17)

> *[The] scope comprises those types of individual components that may provide resources for use in economic activity. […] There are seven individual components of the environment that are considered environmental assets in the Central Framework. They are mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources (excluding timber and aquatic resources), and water resources.* (SEEA CF, 5.10-5.11)

Environmental assets in physical terms consist of cultivated biological resources (produced assets) and natural resources (non-produced assets) in line with the SNA, but also natural assets:

> *[There] is no requirement in physical terms that environmental assets must deliver economic benefits to an economic owner. For example, remote land and timber resources should be included within the scope of the environmental assets of a country even if they do not currently or are not expected to deliver benefits to an economic owner.* (SEEA CF 2012, 5.39)

In monetary terms, on the other hand, the scope is fully aligned with the SNA, as valuation is based on SNA principles. Natural assets with no economic benefit to their defined owner are beyond the SNA production boundary and thus excluded. Environmental assets may therefore, but need not necessarily, be economic assets.

SEEA CF introduces its own environmental asset classification, see Figure 1.

Classification of environmental assets in the SEEA Central Framework

1	**Mineral and energy resources**
1.1	Oil resources
1.2	Natural gas resources
1.3	Coal and peat resources
1.4	Non-metallic mineral resources (excluding coal and peat resources)
1.5	Metallic mineral resources
2	**Land**
3	**Soil resources**
4	**Timber resources**
4.1	Cultivated timber resources
4.2	Natural timber resources
5	**Aquatic resources**
5.1	Cultivated aquatic resources
5.2	Natural aquatic resources
6	**Other biological resources** (excluding timber resources and aquatic resources)
7	**Water resources**
7.1	Surface water
7.2	Groundwater
7.3	Soil water

Figure 1: Classification of environmental asset in the SEEA CF (Table 5.1) (United Nations 2012)

2. System of Environmental-Economic Accounting Ecosystem Accounting (2021 SEEA EA)

The System of Environmental-Economic Accounts Ecosystem Accounting (SEEA EA) is a conceptual framework to compile spatially explicit integrated accounts on ecosystem extent, condition, services and assets. Ecosystems assets as the functional spatial unit of analysis in physical terms are defined as follows:

> *Following the Convention on Biological Diversity (CBD) an ecosystem is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit".* (SEEA EA, 2.6)

> *Ecosystem assets (EAs) are contiguous spaces of a specific ecosystem type characterised by a distinct set of biotic and abiotic components and their interactions.* (SEEA EA, 3.5)

Ecosystem assets are three-dimensional spaces covering the biosphere. As such, the classification for natural capital in ecosystem accounting is an ecosystem typology (e.g. IUCN GET). Similar to the SEEA CF definition of environmental assets, ecosystems can represent economic assets, but are not defined by flows of benefits or ownership. In physical terms, all areas of an accounting area (e.g. a country) are classified as specific ecosystems solely based on their biophysical existence. Besides the spatial dimension, the ecosystem condition account contains other relevant information on the asset in physical terms.

In monetary asset accounts, according to SEEA EA, the value of an ecosystem asset represents the net present value of all ecosystem services provided by the physical asset. Since ecosystem services are contributions to benefits that can represent SNA as well as non-SNA goods and services, the scope is not limited to economic assets. Thus, although the valuation methods may be the same, the approach of valuing entire ecosystem assets rather than singular resources differs significantly from environmental assets (SEEA CF) and natural resources (SNA). Monetary ecosystem assets may complement (through the non-SNA benefits) and partially (e.g. biological resources) but do not fully (e.g. mineral and energy resources) contain natural SNA entities.

3. System of National Accounts (2008 SNA)

The System of National Accounts (SNA) is the international standard framework for compiling national accounts. All economic activities, flows and stocks within the production boundary are included to measure economic activity, ultimately deriving aggregates like the GDP.

The economy is defined by the set of economic units that are resident within an economic territory. Per definition, the productive activity of these units is limited to processes, where outputs are not merely the result of natural processes, but in combination with capital, labour and intermediate inputs. Economic activity is commonly measured in transactions of goods and services between economic units. Economic Assets, e.g. the stocks of natural resources, are owned by economic units and provide future economic benefits, where the scope of the latter is defined by the production boundary. When economic assets are also environmental assets, the SNA distinguishes between produced (cultivated) biological resources and non-produced (non-cultivated) natural resources.

Nature is neither an economic unit nor does it, as an asset, lie fully within the production boundary. This means, although it is the essential source of all production inputs, only those parts that are i) under defined ownership of economic units and ii) expected to generate economic benefits (income/rent or resale value) for that owner are considered natural resources.

> *Natural resources such as land, mineral deposits, fuel reserves, uncultivated forests or other vegetation and wild animals are included in the balance sheets provided that institutional units are exercising effective ownership rights over them, that is, are actually in a position to be able to benefit from them. Assets need not be privately owned and could be owned by government units exercising ownership rights on behalf of entire communities. Thus, many environmental assets are included within the SNA. Resources such as the atmosphere or high seas, over which no ownership rights can be exercised, or mineral or fuel deposits that have not been discovered or that are unworkable, are not included as they*

> *are not capable of bringing any benefits to their owners, given the technology and relative prices existing at the time.* (SNA 2008, 1.46)

The 2008 SNA does not include an explicit definition of the term natural capital. The framework is neither explicitly referring to it as a factor of production nor as a more general store of value. However, by delineating the boundary of what is included (labelled as natural resources) and what is not, the implication is that there are other parts of natural capital, that may provide other (non-SNA) benefits to economic units through final consumption of goods and services (e.g. ecosystem services). One could interpret this as an anthropogenic instrumental view on natural capital, which provides benefits (as defined in the SNA), within and beyond the SNA production boundary.

> *Natural capital is the extension of the economic notion of (produced) capital to the natural environment, i.e. the 'stock' of natural (eco-)systems that yields a flow of valuable (ecosystem) goods or services into the future.* (Radermacher & Steurer 2015)

The SNA accounts for natural resources via its asset classification. Natural resources are spread across produced non-financial (AN1) and non-produced non-financial assets (AN2):

- Fixed assets by type of asset (AN11)
    - Cultivated biological resources (AN115)
        - Animal resources yielding repeat products (AN1151)
        - Tree, crop and plant resources yielding repeat products (AN1152)
- Inventories by type of inventory (AN12)
    - Work-in-progress (AN122)
        - Work-in-progress on cultivated biological assets (AN1221)
- Natural resources (AN21)
    - Land (AN211)
    - Mineral and energy reserves (AN212)
    - Non-cultivated biological resources (AN213)
    - Water resources (AN214)
    - Other natural resources (AN215)
        - Radio spectra (AN2151)
        - Other (AN2159)

4. System of National Accounts (Revision 2025 SNA)

The 2025 Revision of the SNA, currently under global consultation, foresees extensions of the 2008 SNA with respect to natural capital.

- Introduction of a broadened asset boundary (adding renewable energy) and differentiated measurement (mineral and energy resources, biological resources) for specific natural resources.
- An extended asset classification that separates economic produced capital and natural capital in distinct asset classes.

> *The measurement of economic capital falls within the scope of the SNA sequence of economic accounts and encompasses produced non-financial assets, non-produced non-financial assets (e.g. contracts, leases and licences) and financial assets and liabilities while excluding natural resources which are included under natural capital.* (SNA 2025, 2.23)
>
> This classification would also include classes of capital that support a comprehensive wealth perspective but lie outside the SNA boundary, under the condition that such

classes are clearly marked, among which are ecosystem assets. This means, while there is no explicit extension of the SNA's sequence of accounts to ecosystem assets, they will be referred to as an important aspect of comprehensive wealth and feature as a placeholder item

However, this would reduce ecosystem assets to values reflecting only non-SNA benefits, as any assets within the SNA boundary are classified as natural resources. In practice, this would essentially make ecosystem composite assets consisting of natural resources (SNA) and ecosystem assets (non-SNA). This is also acknowledged in Chapter 35 of the Rev 2025 SNA, but it is unclear how this overlap should be dealt with in the classification and/or wealth accounts.

While this framing of natural capital encompasses stocks of natural resources and ecosystem assets, these two categories of natural capital are not mutually exclusive and there is a clear overlap between ecosystem assets and a number of natural resources including land, biological resources and water resources. (Rev 2025 SNA, 35.27)

As mentioned above, the revision is intended to extend and modify the SNA asset classification. Natural resources previously spread across produced non-financial (AN1) and non-produced non-financial assets (AN2) would be grouped in Natural capital (AN3):

- Natural resources (AN31)
    - Land (AN311)
    - Mineral and energy resources (AN312)
        - Non-renewable mineral and energy resources (AN3121)
        - Renewable energy resources (AN 3122)
    - Biological resources (AN313)
        - Biological resources yielding repeat products (AN3131)
        - Biological resources yielding once-only products (AN3132)
    - Water resources (AN314)
    - Radio spectra and other natural resources (AN315)
        - Radio spectra (AN3151)
        - Other (AN3152)
- Ecosystem assets (AN32)

These revision items imply that, in contrast to the 2008 SNA, the term natural capital will be used explicitly. No official definition for natural capital has been included in the revision documents as of now, but a measurement scope is defined:

> *To establish a measurement scope for the stock of natural capital, SEEA defines environmental assets as the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity (SEEA Central Framework, 2.17). From this broad, biophysical scope, two primary measurement categories emerge: natural resources and ecosystem assets.* (SNA 2025, Chapter 35)

Although the Rev 2025 SNA states that "Overall, the combination of natural resources and ecosystem assets provides for the comprehensive measurement of the stock of natural capital", it acknowledges caveats limiting its potential to cover all natural capital:

- The aforementioned overlap of natural resources and ecosystem assets
- The scope is limited to natural capital assets over which ownership rights have been established and that provide economic benefits to their owners

B. Other applications:

The World Bank's Changing Wealth of Nations (CWON) Report refers to two types of natural capital:

- Nonrenewable (fossil fuels and minerals)
- Renewable (agricultural land, forests, protected areas, mangroves, marine fisheries)

When measuring natural capital CWON uses a net present value approach, whereby both SNA-benefits (natural resources) and non-SNA benefits (ecosystem services) are considered.There are also a range of applications from the side of business/financial accounting that have adopted broad definitions of natural capital.

The Natural Capital Declaration (UNEP) aims at promoting the inclusion of risks and opportunities regarding natural capital in the decision-making of financial institutions. Natural capital is defined as follows:

> *Natural capital comprises Earth's natural assets (soil, air, water, flora and fauna), and the ecosystem services resulting from them, which make human life possible.* (UNEP 2012)

The Convention on Biological Diversity (CBD) calls for the engagement of business to achieve its objectives and uses a definition of natural capital from the World Forum on Natural Capital (2017):

> *Natural Capital can be defined as the world's stocks of natural assets which include geology, soil, air, water and all living things.* (World Forum on Natural Capital 2017)

The Natural Capital Coalition uses a definition that stresses the flow of benefits to people:

> *We define Natural Capital as the stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.* (Natural Capital Coalition 2016)

The broad definition used in business (sustainability) accounting can perhaps be explained by the focus on risks of and impact on natural capital for businesses, rather than a comprehensive accounting for natural capital. This is for instance reflected in the double materiality (impact and financial materiality) approach of the EU Corporate Sustainability Reporting Directive (CSRD), where natural capital features in the reporting standards for water and marine resources (ESRS 3), biodiversity and ecosystems (ESRS4) and resource use and circular economy (ESRS 5). This also implies a focus on changes in natural capital rather than assessing stocks: "Of the large number of company natural capital assessments conducted to date, the majority have been primarily concerned with flows" (Natural Capital Coalition 2021). However, the recent inclusion of sustainability reporting in business accounting means that the field is still evolving and may benefit from a clear measurement framework for natural capital, in particular since sustainability reporting will draw on multiple data sources including the SNA and SEEA accounts.

IV. Discussion

A. What is the difference between "Nature" and "Natural Capital" implied in these definitions?

1. Can the various definitions for Nature and Natural Capital form a nested hierarchy?

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) provides a core glossary, which could be used to locate the above definitions in a nested categorization.

Nature as the overarching category may hold both anthropocentric and non-anthropocentric values, in that it is by definition unknowable and only partially perceivable to humans. Environmental assets (SEEA) in physical terms represent the known nature.

> *In the context of IPBES, nature refers to the natural world with an emphasis on its living components. Within the context of western science, it includes categories such as biodiversity, ecosystems (both structure and functioning), evolution, the biosphere, humankind's shared evolutionary heritage, and biocultural diversity.*

Some aspects of Nature known to humans provide beneficial or detrimental contributions to humans' quality of life. Nature that benefits humans represents the source of instrumental value, in particular use-values (ecosystem services, abiotic flows, spatial functions) and non-use values.

> *The direct and indirect contribution of nature's benefits to the achievement of a good quality of life. Within the specific framework of the total economic value, instrumental values can be classified into use (direct and indirect use values) on the one hand, and non-use values (option, bequest and existence values) on the other. Sometimes option values are considered as use values as well.*

Those specific aspects of Nature that are the source of use-values are labelled as *Natural Capital* (in its broad definition). This narrower definition of instrumental value delineates the boundary of natural capital. *Environmental Assets* (SEEA) in monetary terms are also defined by a fund of values approach and coincide with this definition of natural capital.

> *Within the IPBES conceptual framework, [natural capital] is part of the nature category, representing an economic-utilitarian perspective on nature, specifically those aspects of nature that people use (or anticipate to use) as source of Nature's contributions to people.*

Parts of the (broad) natural capital satisfy the economic definition of natural capital as economic assets, namely *Natural Resources (SNA)*. Other parts of natural capital provide use-values both within (overlap with natural resources) and beyond the SNA-boundary and represent *Ecosystem Assets in monetary terms (SEEA).*

2. Natural capital as an "umbrella term"

Following the above categorization, *Natural Capital* can be understood an umbrella term for parts of Nature that:

- …provide beneficial contributions to humans' current or future well-being

- …by way of direct or indirect use,
- …thus generating value from an economic-utilitarian perspective
- …and thereby defined by such value rather than physical existence

In this broad definition natural capital is not inherently a monetary concept, but a physical asset defined by a fund of value approach.

B. Issues with Natural Capital in the Rev 2025 SNA:

1. Natural capital is not standard "store of value"

The definition of assets/capital is remains unchanged from the SNA 2008 to the SNA 2025 Revision:

> *An asset is a store of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another. (SNA 2008, 3.5; SNA 2025, 4.5)*

For non-financial assets, and in particular for natural capital, it implies that natural resources are physical objects that can be stored and used when decided by the unit benefitting from the objects. Such a physical object approach means that objects included in natural capital can be stored and used when decided by the unit benefitting from the objects. This would exclude wind and solar energy. In the physical objects view on capital there is a difference between being useful versus having a value. The wind and solar radiation are useful in transforming kinetic energy into electric current, but since these flows cannot be captured and stored they cannot be transacted and have no exchange value *per se*.

However, the SNA 2025 will include natural resources (e.g. renewable energy), for which value is not defined by transactions, but by a fund of benefits approach. This together with other proposed changes of SNA indicates that the interpretation of the asset definition has changed to incorporate a larger part of natural capital as natural resources. The fund of values approach defines capital as a stream of current and future flows of benefits. This approach calculates a value of the flow by establishing a link between the flow and the income received by the units benefitting, directly or indirectly, from income received from the activity using the flow from the natural source. It is consistent with valuation approaches for certain environmental assets in the SEEA CF and SEEA EA.

> *[...] in an accounting sense, there is no physical stock of renewable sources of energy that can be used up or sold. Therefore, the measurement scope of the SEEA in relation to these sources of energy relates to the amount of energy that is produced [...] (SEEA CF, 5.226-5.227)*

A fund of values approach on the other hand does not demand that humans command when the capital is used. The flow appears and has to be made useful at the same time. In the fund of values approach there is not a necessary relation between the flow and a physical object (e.g. between capture of solar energy and the sun).

2. Definition does not match what is actually measured

The SNA 2025 Revision (final draft) recognizes that, due to its systemic boundary, natural capital is only partially accounted for, yet explicitly refers to natural capital in Chapter 11 on capital accounts.

[...] in the context of the SNA, natural capital is restricted to natural resources
(SNA 2025, 11.21)

It is not clear why the SNA would not internally refer only to natural resources and open up the discussion of accounting for natural capital (it its broad definition) later in Chapter 35 “Measuring sustainability of well-being”. Besides potential confusion and a lack of clarity for users, two issues may arise from this: i) underappreciation of natural capital in public discourse and policy (because the “productive” part of natural capital is easiest to measure) and ii) misinterpretation of depletion and depletion-adjusted aggregates as they are not reflecting degradation of ecosystems but only depletion of natural resources and restrictively implying weak sustainability.

3. Overlap between natural resources and ecosystem assets in natural capital

Although, as mentioned above, the SNA acknowledges that only natural resources are recognised in national accounts and that there is a overlapping scope between natural resources and ecosystem assets, it implies that the value of ecosystem assets is net of any value represented in natural resources:

Natural capital refers to the sum of natural resources and ecosystem assets [...]
(SNA 2025, 35.24)

However, given the overlapping scope of these two components, careful partitioning of monetary values is required if there is a requirement for aggregation so that there is no double counting.
(SNA 2025, 35.30)

Ecosystem assets are not recognised in the system of national accounts, mainly because no monetary benefits can be derived from them.

(SNA 2025, 11.180)

An alignment of methodology when it comes to valuation appears necessary for any partitioning of monetary values. Consequently, the use of the term “ecosystem assets” is, at the very least, unfortunate in that it differs from what is defined as ecosystem assets in monetary terms in the SEEA EA.

Also, the necessary partitioning of the values may not always be possible.

4. Further issues

There are further issues that may arise from the introduction of natural capital and the new asset classification in the SNA 2025, but which are currently still work in progress and have to be reassessed once the SNA 2025 is set in stone. These include:

- The recording of regeneration and depletion of biological resources
- Implications of accounting for composite natural capital assets
- Classification of “land improvements”

C. Implications for the SEEA CF (and SEEA EA):

1. Alignment in terminology?

The 2025 SNA refers to SEEA regarding the definition and measurement scope of comprehensive natural capital, equating it to environmental assets.

> SEEA provides the international standard to measure natural capital and has agreed concepts, definitions and accounting treatments for measuring the components of natural capital [...] (SNA 2025, 35.24)

It makes sense that SEEA does in fact remain the authoritative framework to comprehensively define and measure natural capital, given its broad systemic boundaries that include both physical and monetary assets regardless of economic benefits and defined ownership as well as ecosystem assets. However, the SEEA does not currently refer to nor use the term natural capital.

One option is to nest natural capital as a subset of environmental assets and ecosystem assets in physical terms (see Figure 2, left). Since ecosystem assets, environmental assets and natural resources have different systemic boundaries in physical terms, only a subset of the physical assets is considered natural capital (even though hardly any ecosystem and resources will “escape” the above definition).

So while there may be remote environmental or ecosystem assets beyond the natural capital boundary in physical terms, these generate no value from an economic-utilitarian perspective. This means that natural capital in monetary terms includes all assets that generate such value (meaning that monetary environmental and ecosystem assets are a subset of natural capital in monetary terms)(see Figure 2, right)..

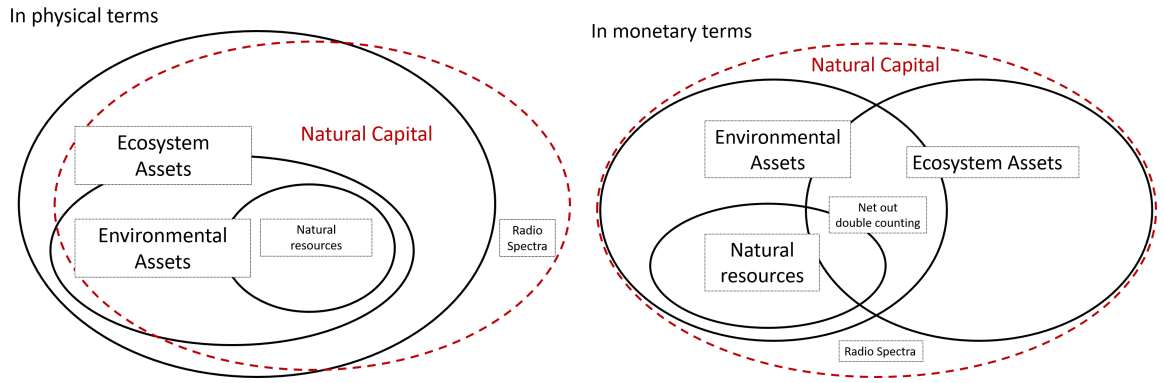

Figure 2: Asset boundaries for an “umbrella” definition of natural capital in monetary and physical terms

Another option is of course to refer to and explain the SNA notion of natural capital and its relation to environmental assets (physical and monetary) and ecosystem assets without any changes to the SEEA CF 2012 asset classification.

2. Alignment in scope and methodology?

Natural resources in the SEEA CF and the SNA are currently not aligned (e.g. radio spectra, resources beyond the SNA boundary). Furthermore, the overlap between natural resources

and ecosystem assets in the SNA is also reflected in the overlap between environmental assets and ecosystem assets in SEEA. Contrary to the SNA (which acknowledges the issues, but considers it beyond its boundary), the SEEA (and in particular the SEEA CF) should include guidance to reconcile any double counting between the two types of assets (elaboration of SEEA EA Section 11).

While the definition and scope of natural capital may include the instrumental value of ecosystem assets, whether and how valuation of ecosystems assets is feasible and conceptually sound is an issue of its own. It should be noted that the monetary valuation of ecosystem assets in SEEA EA is not part of the statistical standard and any reference to these chapters in defining the scope and methodology in SEEA should reflect this.

Depending on the final asset classification of the SNA 2025, there may be differences to what is recorded as monetary value of land under different land uses in the SNA and the SEEA CF (e.g. forest land, soil resources).

3. Implications for weak and strong sustainability analysis

Regarding the capitals approach, definitions of sustainability typically circle around intertemporal non-declining wealth or utility.

> *Sustainable development is development that ensures non-declining per capita national wealth by replacing or conserving the sources of that wealth; that is, stocks of produced, human, social and natural capital. (SEEA 2003)*
>
> *[D]evelopment is sustainable if it does not decrease the capacity to provide non-declining/capita utility for infinity (Neumayer 2003)*
>
> *[T]he sustainability of past developments is implied if the level of [comprehensive] wealth in real terms is non-declining" (SNA 2025, 35.105)*

The assessment of sustainability depends on the degree of substitutability between different capitals, which is, due to the complexity and regionality of natural phenomena, still not fully known..

Weak sustainability: Measuring depletion of natural resources (as intended in the SNA 2025) is not sufficient to indicate whether natural capital is used sustainably, even from a weak sustainability approach that assumes substitutability between capitals. In particular, depletion-adjusted aggregates are difficult to interpret (e.g. net domestic product compared to GDP) without looking at degradation as well.

> *Therefore we have to value natural capital depletion (i.e. the economic value of a quantity reduction in a natural resource) and degradation (i.e. the economic value of damage to natural capital quality). Otherwise, the sustainability planner cannot know whether natural capital losses are being compensated by equivalent or greater capital investments elsewhere in the economy.* (Dietz & Neumayer 2007)

Strong sustainability: Any type of strong sustainability concept requires information in physical terms of existing stocks and their changes, as well as on the *potential* of the ecosystem to provide essential life-supporting ecosystem services.

Implications for SEEA:

No assessment of sustainability should be undertaken with measures of natural capital alone, even when considering its broad umbrella definition (natural resources + ecosystem assets). The SNA 2025 refers to concepts of both weak and strong sustainability, arguing that natural capital can support both views. However, there is no reference to other conceptual and methodological guidance or data sources that would complement the elements reported in the SNA.

The SEEA CF is currently not referring to any sustainability concept, despite containing much, but not all, of accounts that can inform on sustainability. By defining and guiding compilers to measure (in physical terms) and value natural capital, SEEA currently provides "tools" to adopt a weak sustainability approach, while sustainability reference values that allow for a strong sustainability perspective are not appropriately represented. In fact, monetising environmental accounts is a necessary (but not sufficient) condition for creating a tool that allows the substitution of different capitals (Surun, 2023). Among the possible design choices for monetary accounts, the SEEA has chosen all those that make it possible or even favour the substitution of capitals: an anthropocentric perspective representing only ecosystem services (and not pressures and impacts); evaluation of the net present value of these services; aggregation in a green GDP. However, various past (Hueting, 2013, SEEA 1993) and recent (Vanoli, 2017, Kervinio and Surun, 2023, Usabiaga et al. 2024) studies have made different choices, allowing decisions to be taken partly (in the case of the 1990s) or fully (in the case of more recent studies) from a strong sustainability perspective. They propose monetary accounts based on a conception of capital as the principal of a debt (an entity to be preserved), and not as an asset. Consequently, their monetary valuation is made at the cost of the actions to be implemented to preserve this capital. Relationships with these entities are mainly represented on the liabilities side, in debt accounts, the repayment of which cannot, by its very nature, be substituted by other transactions.

The precedent of the SEEA CF had featured an explicit section discussion the capitals approach and sustainability concepts, stating:

> *The system [SEEA] has not been designed to serve any particular perspective and, indeed, should be of considerable value regardless of the userís particular point of view on the concept. (SEEA 2003)*

With this in mind, the SEEA CF should consider to address i) the potential use of SEEA of the various SEEA accounts to inform on sustainability from different perspectives and ii) consider the include accounts or give references to cover all necessary aspects. In particular, the following aspects are required:

- *Natural capital in the SNA* (natural resources) covers:
    - Value of natural resources
    - Depletion (natural resources in physical terms, flows/extractions)
- *Natural capital (umbrella term)* additionally requires:
    - Value of ecosystem assets (avoiding double counting with natural resources)
- *Natural capital* accounting that can comprehensively inform on *sustainability* additionally requires:
    - Environmental assets (in physical terms), incl. quality
    - Ecosystem assets (in physical terms), incl. condition

- Sustainability reference values
- Value of degradation

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