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# Strong sustainability in the SEEA and the wider indicator landscape

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## Abstract

The System of Environmental-Economic Accounting (SEEA) remains neutral when it comes to the weak and strong sustainability worldviews. However, although its manuals do not contain any references to these concepts, it can support both through physical and monetary accounting. Given that strong sustainability is better suited to monitor environmental sustainability, we provide insights into how SEEA can contribute to promote the use of strong sustainability indicators.

From a strong sustainability perspective, environmental sustainability requires identifying elements of natural capital to be preserved (critical natural capital) and at the level at which they should be preserved (reference values). SEEA and its manuals do not explicitly define the first element, but the concept of 'reference values' is implicitly embedded with the 'ecosystem condition accounts' introduced in the Ecosystem Accounting (EA) manual. As such, EA is the most relevant element of the SEEA in terms of advancing strong sustainability accounting. Given that ecosystem condition accounting is still in its early stages and that ecosystem condition is currently challenging to determine, three actions are proposed to better integrate strong sustainability in SEEA. First, the next revision of the SEEA Central Framework should be more explicit in how SEEA supports weak and strong sustainability. It should also consider how SEEA is

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linked to the wider indicator landscape (including the Sustainable Development Goals and the Global Biodiversity Framework). Second, ecosystem condition accounting needs to be further developed, as the more abundant extent accounts cannot capture the quality of ecosystems. Third, ecosystem condition accounting could build on other strong sustainability indicator initiatives such as Planetary Boundaries or the Environmental Sustainability Gap framework that have consistently integrated reference values in the accounting practices. These actions would provide additional means to interpret environmental sustainability beyond the direction of progress as is often the case.

## Keywords

strong sustainability, SEEA, natural capital, ecosystem accounting, sustainability

## Introduction

There are two different worldviews that explain the relationship between the environment and the economy in the context of sustainable development: weak versus strong sustainability. The main distinguishing feature between these two is in the relationship between different types of capital (natural, manufactured, social and human) that are key determinants of human welfare. The first worldview, weak sustainability, places the environment at the same level as the economy by assuming that the functions provided by natural capital are interchangeable with those provided by other types of capital. The latter, strong sustainability, sees the economy as a subsystem of the environment and, therefore, views this relationship as complementary, rather than compensatory. Thus, the substitution capacity between the functions provided by different types of capital is limited under this perspective. For an extensive description of the theoretical underpinnings of these two worldviews, we refer the reader to previous literature (Neumayer 2003, Ekins et al. 2019, Godin et al. 2022) .

The ongoing widespread environmental degradation shows that weak sustainability has failed to reconcile development with environmental sustainability. Well-known weak sustainability metrics that measure wealth (Managi et al. 2024, WB 2024) take the form of composite monetary indicators that incorporate the monetary valuation of natural capital with the value of other capitals. In these cases, non-declining per capita wealth is considered to represent sustainability conditions (McLaughlin et al. 2024). For instance, the World Bank argues that these conditions are met at the global level (WB 2024), while, according to Managi et al. (2024), there has only been a very slight decrease of per capita wealth in the period 1990-2019. At the national level, both sources report many countries that have increased their per capita wealth under the period assessed because the loss of natural capital is being compensated by investments (especially) in manufactured and human capital. These messages around global and national sustainability are hardly reconcilable with current environmental trends that indicate that human actions are responsible for being close to transgressing several climate tipping points (Armstrong McKay et al. 2022), for very concerning biodiversity loss trends (IPBES

2019) and for the disruption of several Earth System processes (Richardson et al. 2023). In fact, Managi and Kumar (2018) in page xvi clarify that while "[u]nder a weak substitutability criteria, the world has been experiencing sustainable growth, […] the world would likely not satisfy sustainability under a strong substitutability criteria". Given that the substitutability assumptions in weak sustainability do not hold to scrutiny (Cohen et al. 2019) as evidenced by ever increasing environmental degradation, we contend that strong sustainability is better suited to describing the biophysical systems that underpin the social and economic dimensions of sustainability.

So far, literature on strong sustainability and natural capital accounting (the latter of which encompasses ecosystem, energy, water, biodiversity and other accounting practices), has evolved separately. Nonetheless, there are overlaps, particularly in the context of the System of Environmental-Economic Accounting (SEEA) (Dietz and Neumayer 2007). As an international statistical standard, SEEA can serve as a bridge to major indicator initiatives such as the Sustainable Development Goals (SDGs) (UNEP-WCMC and UNSD 2019), as well as to biodiversity (IPBES 2019, UNDESA 2020a) and climate policies (UNDESA 2020b). Nonetheless, to date, the uptake of SEEA results in policy decisions is limited (Ruijs et al. 2019, Fairbrass et al. 2020), suggesting SEEA needs to increase its policy relevance and adapt the supply of natural capital accounts to the users' needs. In view of a growing interest in strong sustainability indicator frameworks such as Planetary Boundaries (Rockström et al. 2009) and the Environmental Sustainability Gap (ESGAP) (Usubiaga-Liaño and Ekins 2021a), understanding whether SEEA can provide insights into strong sustainability or whether it can reinforce this perspective is relevant and timely.

There have been limited efforts to understand the link between SEEA and strong sustainability, with the most notable exception of the work by Dietz and Neumayer (2007). The authors assessed the extent to which the 2003 version of the SEEA handbook (UN et al. 2007) could support weak and strong sustainability. At the time, they argued that SEEA is not intended to support a particular paradigm of sustainability or its measurement. Instead, SEEA accounts could be used to value natural capital (weak sustainability) or to quantify critical natural capital (i.e. those elements providing irreplaceable functions) and the costs of protecting its integrity (strong sustainability). In particular, in the 2003 SEEA manual, the strong sustainability argumentation relied on a generic explanation around critical natural capital and the levels at which this needs to be maintained. A similar conclusion was formulated by Bartelmus (2008), who argued that SEEA 2003 missed the opportunity to build a link between its physical accounts and critical natural capital. Thus, we argue that there are three main reasons for re-evaluating the link between SEEA and strong sustainability, especially given the developments in both since this initial assessment by Dietz and Neumayer (2007). First, literature on sustainability reference values has evolved considerably through different indicator frameworks that have now integrated them (Vea et al. 2020, Usubiaga-Liaño and Ekins 2021a, Richardson et al. 2023). Second, the SEEA Central Framework has not only been updated (UN et al. 2014), but a series of thematic extensions covering different environmental domains have been edited (UNDESA 2012, UNDESA 2019, UN 2021),

including a series of pilots across several countries (Hein et al. 2020). Last, SEEA has evolved from an isolated handbook for natural capital accounting to a framework meant to support wider indicator initiatives (UNEP-WCMC and UNSD 2019, UNDESA 2020a, UNDESA 2020c).

Against this background, the main goal of this paper is to assess the overlaps between strong sustainability and SEEA considering the wider indicator landscape. Fig. 1 shows the general workflow to help the reader navigate the paper. Thus, the paper begins by examining SEEA through the lens of strong sustainability. The review considers the SEEA Central Framework, as well as on the SEEA Ecosystem Accounting, SEEA Water, SEEA Energy and SEEA Agriculture, Forestry and Fisheries manuals, as these provide a wide coverage of topics. The insights gained from the analysis are then used to examine wider indicator initiatives in which SEEA can play a relevant role in indicator compilation. More specifically, we single out the SDGs for its broad focus and the post-2020 Global Biodiversity Framework (GBF). After that, entry points to integrate strong sustainability in SEEA and the wider indicator landscape are identified with the goal of reinforcing the strong sustainability perspective in SEEA and related indicator initiatives. Finally, the last section elaborates on the conclusions.

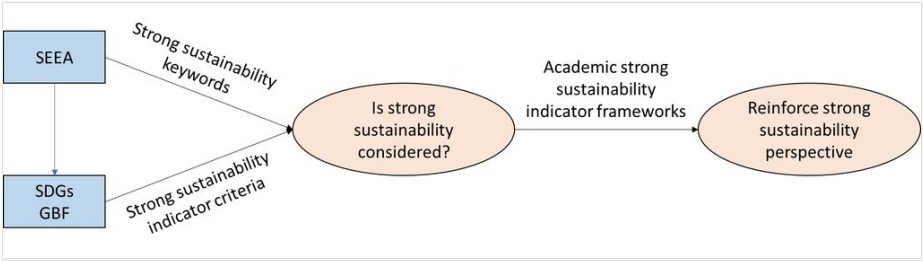


Figure 1.

General workflow of the paper.

Note: SEEA: System of Environmental-Economic Accounting, SDGs: Sustainable Development Goals, GBF: Global Biodiversity Framework.

## Strong sustainability in the SEEA

SEEA is an international statistical standard that provides agreed concepts, definitions, classifications and accounting rules to generate statistics that shed light on the interactions between the economy and the environment (UN et al. 2014). The system has evolved from a handbook published in 1993 that was considered to be work in progress towards an agreed statistical standard being used by multiple countries to compile economic and environmental statistics. SEEA comprises a Central Framework (UN et al. 2014) with thematic spin-offs covering aspects such as energy, water and ecosystem accounting, amongst others (UNDESA 2012, UNDESA 2019, UN 2021). The Central Framework provides guidance on three main aspects: environmental flows, stocks of natural capital and economic activity linked to the environment. Given that the weak and

strong sustainability propositions relate to capital stocks, the stocks of natural capital are the key aspect to be scrutinised in the context of this paper.

SEEA, remains neutral when it comes to the weak and strong sustainability propositions (Bartelmus 2007, Dietz and Neumayer 2007, McGrath and Hynes 2020, Comte et al. 2022). In fact, the key documents do not contain any of the terms. As argued by Dietz and Neumayer (2007), both weak and strong sustainability rely on physical natural capital accounting as a starting point. Thus, different valuation techniques can be used to assess natural capital depletion or degradation and generate environmentally-adjusted monetary macro-aggregate figures such as wealth (Managi et al. 2024, WB 2024) or the Genuine Progress Index (Kubiszewski et al. 2013, Kenny et al. 2019). To support strong sustainability, physical natural capital accounting needs to be used either to quantify the state of critical natural capital or the cost of maintaining its integrity (Dietz and Neumayer 2007). Critical natural capital represents the elements of natural capital that provide irreplaceable functions (Ekins et al. 2003). For this reason, critical natural capital is considered invaluable by definition (Farley 2008). In this line, strong sustainability requires functions that underpin the provision of resources, the regulation of global and regional biogeochemical cycles and that support life, human health and welfare to be maintained over time, given that these define the capacity of natural capital to provide ecosystem services (Ekins et al. 2003).

## Critical natural capital in the SEEA

There are two central aspects to the quantification of critical natural capital. First, there needs to be an understanding of criticality and on which elements of natural capital are critical. Second, a sustainability reference value that indicates the condition at which those elements need to be preserved. This is a must considering that the term sustainability refers to sustaining.

Regarding the first issue, several criteria have been proposed to determine criticality. ‘Importance’ is the most widely used one, in particular ecological importance (e.g. naturalness, biodiversity, rarity, vulnerability, functionality etc.) which relates to life support and ecological services (Chiesura and Groot 2003, Groot et al. 2003). Nonetheless, natural capital also contributes to different spheres of human well-being, so importance can also be determined from a social (e.g. health, amenity, spirituality, heritage etc.) and economic perspective (Groot et al. 2003, IPBES 2019). Other factors such as ‘threat level’ (e.g. based on resilience or ecosystem quality/quantity) can be used in combination with importance to determine criticality (Groot et al. 2003, Brand 2009). This would include elements of natural capital that are important, but not under threat, less important, but threatened or important and threatened at the same time. As natural capital is a multidimensional concept and its criticality dynamic, the elements that are considered critical will vary depending on the geographical context (Groot et al. 2003) and the perceived importance (Chiesura and Groot 2003).

Two decades ago, it was argued that it was not possible to identify the critical elements of natural capital (Ekins et al. 2003, Farley 2008). The term is rarely used in quantitative

assessments, so only a few authors have tried to identify explicitly specific elements of critical natural capital since then. Some authors have assumed that some elements of natural capital such as forests (Bennich et al. 2021), water resources (Dong et al. 2021) and land (Chen et al. 2020) are critical in their own right. Others have mapped the assets that provide a limited set of key functions (Lü et al. 2017, Liu et al. 2020) or that have some key characteristics, such as maintaining self-regulatory, self-organising and stabilising properties of ecological processes (Mora 2019). All these examples referred to specific locations, mostly countries. Chaplin-Kramer et al. (2023) represents a notable exception in that they mapped critical natural assets providing 90% of 14 ecosystem services. As the authors noted, the concept of critical natural assets was related, but not the same as critical natural capital. Despite the progress made in identifying specific elements of critical natural capital, the original conclusion from Ekins (2003) stands. Ekins argued that it was not possible to identify all the elements of critical natural capital, since "environmental functions may be enabled or performed by processes resulting from the interactions between elements of natural capital as much as from the elements themselves. These interactions derive from certain characteristics of the natural capital stock, and it is the characteristics that need to be safeguarded if the functions are to be maintained" (Ekins 2003, p. 278). It is worth noting that inroads have been made elsewhere in the social-ecological resilience literature, which defines criticality as resilience of a particular system, such that systems can persist, adapt or transform in the face of change (Folke et al. 2010), without tipping over or crossing regime shifts (Biggs et al. 2009).

Beyond the specific elements of natural capital that can be considered critical, a common issue relates to the condition at which these elements need to be preserved to ensure the maintenance of their functions. There are different typologies of these 'sustainability reference values'. For instance, Moldan et al. (2012) refer to 'soft' and 'hard' targets. Soft targets are solely based on scientific knowledge, while hard targets are set through political processes. Usubiaga-Liaño and Ekins (2021a) refer to 'environmental limits' and 'environmental standards' as forms of soft targets and to 'environmental policy targets' as hard targets. Environmental standards share similarities with the notion of 'science-based targets' (Andersen et al. 2020) and planetary boundaries (Rockström et al. 2009). These different types of reference values are defined by separate, but interacting scientific, political and administrative spheres (Kervinio et al. 2023).

There is only one explicit reference to critical natural capital in the SEEA Central Framework and its thematic extensions. The Central Framework, which includes subsections on various resources such as minerals, energy, soil, water and timber, contains generic references to sustainable yields and similar concepts related to critical natural capital (UN et al. 2014), but not to critical natural capital itself. The SEEA Ecosystem Accounting manual, on the other hand, argues that it can support the quantification of critical natural capital (UN 2021), yet it does so in a rather vague manner. As they note in page 112:

"[t]he assessment of ecosystem capacity to supply ecosystem services will depend on complex interrelationships of multiple indicators for determining threshold levels to define

sustainability. Connecting the critical levels of ecosystem capacity back to the ecosystem condition variables that have the highest influence on specific ecosystem services is an important area of future research. Such research would support information in the ecosystem accounts being used to quantify the 'critical natural capital' concept described in economics (Ayres et al. 2001) or the 'planetary boundaries' concept in ecology (Rockström et al. 2009)".

SEEA EA also argues that ecosystem condition variables need to be compared with a sustainability reference value to quantify critical natural capital (Keith et al. 2020). Specifically, the manual mentions in page 112:

"(…) indicators of ecosystem condition could be combined with information on ecological thresholds (e.g. concerning points of change in ecosystem type) to assess the risk of change or, alternatively, to assess the degree of resilience within ecosystems under conditions of change".

Despite this statement, SEEA EA does not, in fact, determine such thresholds, although it provides some guidance on how to establish them as shown later. As explained above, the existence of sustainability reference values is a key criterion to monitor strong sustainability. Without such reference values, environmental sustainability could not be adequately quantified, as the indicators would only inform about the direction of change (i.e. whether the value is increasing or decreasing) (Vallecillo et al. 2022). Thus, the condition accounts described in chapter 5 of the SEEA EA manual are the key entry point to integrate strong sustainability in the SEEA.

## Ecosystem condition in the SEEA

### Ecosystem condition

Chapter 5 of the SEEA EA manual states that ecosystem condition is strongly related to ecosystem integrity, which, in turn, determines the capacity to supply ecosystem services. Condition is assessed in relation to an ecosystem's composition, structure and function. Biodiversity in all its facets is an integral part of it (Pereira et al. 2013). Condition is commonly accounted for in biophysical terms, although the resulting information can be used to build monetary indicators based on, for example, restoration costs (Ekins 2011, Kervinio et al. 2023).

Condition is characterised through different variables intended to represent abiotic, biotic and landscape features of ecosystems. These variables are then rescaled using reference values (termed reference levels in the manual) to compute ecosystem condition indicators that can later be aggregated (or not). The reference values used are intended to reflect high and low condition scores for individual variables and can, therefore, use different criteria depending on whether natural, semi-natural or anthropogenic ecosystems are considered. Nonetheless, depending on the definition, separating natural, semi-natural and anthropogenic might not always be easy, since humans have shaped most of terrestrial nature for more than 12,000 years (Ellis et al.

2021). In this line, some recent literature on co-production of ecosystem services suggests that they result from an interaction between ecological and social processes (Palomo et al. 2016, Schröter et al. 2021, Kachler et al. 2023). Reference conditions, on the other hand, represent a consistent set of reference values, which will likely be ecosystem-specific and, therefore, differ across ecosystems (Keith et al. 2020).

Composite indicators can be constructed based on normalised ecosystem condition variables (i.e. rescaling to a dimensionless score between 0 and 100 using reference values), to provide more digestible information on condition to non-expert users. This aggregation can, for example, qualitatively categorise condition (e.g. excellent, good, moderate, bad) as is done in Europe in freshwater systems (European Parliament and European Council 2000).

To date, 41 countries have compiled SEEA ecosystem accounts of various types (see Maes et al. (2020) and Bagstad et al. (2021) for some examples), a number that has almost tripled since 2017 (UNSD 2023). Ecosystem extent accounts, which report on the size and spatial distribution of ecosystems, are more common than ecosystem condition accounts, at least in Europe (Lange et al. 2022). After all, there are no condition accounts without extent accounts. Likewise, the availability of data on condition not only tends to be scarcer than data on extent (Grilli et al. 2021, Mengo et al. 2022), but is also biased towards some type of variables (e.g. abiotic) (Maes et al. 2020).

A recent review showed that the use of reference values in ecosystem condition accounts is not a standard practice, although it is found often enough (Maes et al. 2020). For instance, reference values can be represented through the values found in pristine or other reference ecosystems for selected variables or through well-established concepts, such as critical loads (UBA 2004), limits to air pollutant concentrations (WHO 2005), tolerable soil erosion rates (Verheijen et al. 2009) etc. In some other cases, the reference value represents a point in time such as pre-industrial periods – for example the biodiversity intactness index uses this approach to determine intactness (Scholes and Biggs 2005). The indicator selection criteria used can be an important factor to explain the limited integration of reference values (especially sustainability reference values) in condition accounts. Czúcz et al. (2021) describes 12 criteria, "directional meaning" being the most important one in the context of this argumentation. Directional meaning refers to the capacity of a variable to be interpreted in a normative context. In other words, the user should be able to interpret whether the condition is improving or worsening depending on the evolution of the variable. The existence of a threshold or a sustainable reference value, which not only fulfils the directionality criterion, but also provides contextual meaning through the value itself, could be seen as a sub-criterion of directional meaning. This sub-criterion has been used for the selection of unrelated environmental indicators ( Niemeijer and Groot 2008, Moriarty et al. 2018) and is at the core of strong sustainability indicators (Usubiaga-Liaño and Ekins 2021a). The absence of this sub-criterion opens the range of variables to be included. After all, all the variables that can be used to characterise condition do not have reference values with a clear analytical rationale, let alone sustainability reference values.

### The link between ecosystem condition and ecosystem services

Ecosystem condition is closely related to the concept of ecosystem services (Maes et al. 2020) and, by extension, to the concept of nature's contributions to people (Kadykalo et al. 2019). In fact, ecosystem condition underpins the provision of ecosystem services. This is also evident in other definitions of ecosystem condition (Keith et al. 2020).

One of the key criteria for the selection of ecosystem condition indicators is the existence of a conceptual link to the provision of specific ecosystem services, although this link does not need to be formulated in quantitative terms (Czúcz et al. 2021). Thus, the compilation of ecosystem condition and ecosystem service accounts is done separately (UN 2021). Nonetheless, these accounts can maintain internal consistency (Keith et al. 2020) and even be integrated more closely together through the concept of ecosystem capacity (La Notte et al. 2022a). Ecosystem capacity refers to the ability of ecosystems to supply ecosystem services under current ecosystem condition, management and uses in a sustainable way, rather than the actual flow of ecosystem services (Schröter et al. 2014, La Notte et al. 2019). While at the moment this integrative approach is not widely used (see Martini et al. (2024) for an example), some information exists on how the connection between ecosystem condition and ecosystem service indicators could be established (Lof et al. 2019, La Notte et al. 2022a, Rendon et al. 2022). Given that some ecosystem services, such as the provision of renewable resources, are considered to have 'sustainability thresholds' (La Notte et al. 2022b), this also provides a promising link to condition accounts through reference values.

## Biodiversity in the SEEA

Biodiversity can be considered an element of natural capital on its own right, given that it underpins the provision of ecosystem services (Cardinale et al. 2012, Mace et al. 2012, Reyers et al. 2012). The concept is multidimensional and encompasses ecosystem, species and genetic diversity (UN 1992).

Chapter 13 of SEEA EA describes biodiversity accounts. Although the chapter refers to species and genetic diversity accounts, the accounts do not provide a direct measure of biodiversity, but rather data that can support its assessment. Likewise, biodiversity accounts have been designed in close relationship with ecosystem accounts, rather than a standalone instrument (King et al. 2021). Thus, there is a bidirectional relationship in that biodiversity accounts can support ecosystem condition assessments by including biodiversity variables, while data from ecosystem accounts can serve as input for biodiversity accounts.

The SEEA EA manual does have a generic reference to sustainable harvesting rates, although it lacks any specificity. Thus, in page 279, it reads: "[f]or species to be harvested on a sustainable basis, their stocks need to be quantified and assessed in the context of the supply and use of the services". Similarly, UNDESA (2020a) mentions the relevance of finding tipping points of no return in the context of ecosystem diversity, but it argues

that these are difficult to quantify. This is also the case in Ruijs and Vardon (2018), who also highlight the relevance of setting sustainability reference values.

In any case, biodiversity accounting in the context of SEEA is less mature than ecosystem accounting, both in practical and conceptual terms. Relatively little attention has been placed in species accounts (with limited examples on several fisheries species in South Africa (Statistics South Africa 2015)), while the issue of genetic diversity has been neglected so far (Ruijs and Vardon 2018). Nonetheless, work is underway to develop more detailed guidelines to compile these types of accounts.

## Other elements of natural capital in the SEEA

Ecosystems and biodiversity are an integral part of natural capital, but by no means the only ones. In this regard, chapter 5 of the SEEA Central Framework briefly introduces accounting practices for various assets such as mineral and energy resources, land, soil, timber, aquatic resources, other biological resources and water (UN et al. 2014). As they argue, the Central Framework does not seek to measure degradation, which is considered to be related to the qualitative status of natural capital. Nonetheless, some features of degradation are linked to the concept of depletion, which features prominently in the document. Depletion reflects the "decrease in the quantity of the stock of a natural resource (…) that is due to the extraction (…) occurring at a level greater than that of regeneration" (p. 148). In this context, the document contains a few references to concepts that can be construed as sustainability reference values, although these are rather generic and not described in detail. For instance, the term 'sustainable yield' is used several times referring to environmental assets, in general (pp. 147-148) and timber (pp. 195-196) and aquatic resources (pp. 205-206, 209), in particular. In other cases, the Central Framework refers to relevant aspects of quality of the resources, such as soil health (pp. 187, 191), as aspects not covered in the document. The environmental protection expenditure account of the SEEA Central Framework can also be an important (but not sufficient) building block to link critical natural capital and the possibility to conduct monetary valuation through maintenance and restoration costs (Bartelmus 2014).

The thematic manuals are not much more specific on sustainability reference values. For example, the SEEA manual on agriculture, forestry and fisheries (FAO and UNSD 2020) does not define a concept of sustainability. Nonetheless, it intends to provide relevant information to monitor the sustainability of the resources used to undertake agricultural, forestry and fisheries activities, specially water and energy. Thus, it does mention 'sustainable levels' in this regard (p. 8), but no details are given in terms of what this could mean. The SEEA Energy manual (UNDESA 2019) does not contain references to sustainable reference values either. While they define depletion in physical terms, no reference values are provided to monitor the sustainability of the stocks. Instead, depletion figures are used to adjust macroeconomic aggregates.

The SEEA Water manual (UNDESA 2012), on the other hand, provides a definition of sustainable water use, which is considered "the level of abstraction that meets the needs

of the current generations without compromising the ability of future generations to meet their own needs (…)" (p. 96). Then, they specify that "sustainable, long-term water use that does not compromise the ability of ecosystems to supply water services in the future, including both human water requirements and ecological water requirements" (p. 180). In this line, they argue that water use needs to be compared with available water resources (stocks) to provide insights into water stress conditions, although they acknowledge the limitations of treating water stress at the national scale, given its specificities related to time and space. Beyond definitions, the manual specifies several indicators that can be calculated based on the water accounts, some of which are intended for water stress (namely, index of non-sustainable water use, relative water stress index, surface water as a percentage of total actual renewable resources, groundwater as a percentage of total actual renewable resources). While these indicators require a sustainable reference value that denotes stress conditions, such value is only provided for one of them (relative water stress index).

## To which extent is strong sustainability embedded in the SEEA?

The previous subsections examine the extent to which strong sustainability is embedded in SEEA based on the use of specific terms in SEEA manuals. The main results are summarised in Table 1. While terms such as 'strong sustainability' and 'critical natural capital' are rarely used, the SEEA EA manual uses reference levels to monitor ecosystem condition. The use of reference values is a key aspect of strong sustainability, in that monitoring the maintenance of the functions provided by natural capital requires measuring compliance with adequate reference values. Other manuals, including the SEEA Central Framework, do mention concepts such as 'sustainable yields', 'sustainable levels' or 'sustainable use', but these only have a contextual role. Thus, the SEEA EA manual and, in particular, the chapter on ecosystem condition accounts represents the main contribution of SEEA in the context of strong sustainability.

Table 1.
Coverage of strong sustainability and related concepts in SEEA manuals.

| Concept | Coverage in SEEA |
|---|---|
| Strong sustainability | The term is not mentioned in the Central Framework or in the SEEA EA, SEEA Water, SEEA Energy and SEEA Agriculture, Forestry and Fisheries manuals. |
| Critical natural capital | The term is only mentioned once in the SEEA EA manual, but the need to use thresholds (reference levels) to determine the condition of critical natural capital is acknowledged. |
| Reference values | The SEEA EA manual defines a typology of reference levels and provides guidelines to establish them, although it does not determine reference levels. Reference levels are to be used to determine ecosystem condition. Related terms such as 'sustainable yields', 'sustainable levels' or 'sustainable, long-term water use' are mentioned in the Central Framework and in the manuals on SEEA Agriculture, Forestry and Fisheries and the SEEA Water manuals, but just for contextual purposes. |

## SEEA as a bridge between strong sustainability and broader indicator initiatives

Building on the insights above, this section assesses the extent to which SEEA can support policy-relevant indicator frameworks, such as the SDGs and the GBF and whether these already integrate strong sustainability elements. It does so by checking whether key terms identified above (namely strong sustainability and critical natural capital) are used in official documents and assessing whether the indicators included in those frameworks use relevant criteria as identified in the literature.

### Sustainable Development Goals

SEEA can provide the basis to compute several SDG indicators directly or to provide supplementary data for others (UNDESA 2020c). While doing so, it can increase data quality and the comparability of inter-country statistics (UNSD 2015, Bann 2016, Vardon et al. 2018). As such, the UN Statistical Commission has shown a "strong support for using SEEA in compiling Sustainable Development Goal indicators (…)" (UNSC 2018, p. 18).

In a review of indicators, the UN Committee of Experts on Environmental-Economic Accounting argued that SEEA can support 40 SDG indicators across the SDGs 2 (zero hunger), 6 (clean water and sanitation), 7 (affordable and clean energy), 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), 11 (sustainable cities and communities), 12 (responsible consumption and production), 14 (life below water) and 15 (life on land) (UNCEEA 2018). While currently some of them are fully aligned with SEEA accounting rules, SEEA is still relevant to other SDG indicators that are still not aligned. In a different review, UNEP-WCMC and UNSD (2019) found 21 SDG indicators with the potential for full alignment with SEEA and two with potential for partial alignment. Amongst these indicators, they considered the SEEA EA and the SEEA Water manuals to be the most relevant ones. While the latter review did not consider indicators for the SDGs 7, 8, 9 and 12, both of them show an important role to be played by the SEEA in the compilation of SDG indicators. These insights are consistent with those from a survey where 14 experts on natural capital accounting from developed countries unanimously agreed on the potential of SEEA to support SDG indicator compilation (Pirmana et al. 2019). According to the respondents, the water, energy and air emission, and forest accounts had the highest potential to contribute to the SDG indicators, in particular those from SDGs 6, 7 and 15. Bann (2016), on the other hand, highlighted the role of water and forest accounts in supporting SDGs 6, 10, 13 and 15. All in all, these studies show the theoretical potential of the SEEA to support SDG indicator compilation, although the extent to which the SDG indicators are aligned with the strong sustainability proposition is not considered.

As in the case of SEEA, there are no references to weak or strong sustainability or criticial natural capital in the main document of Agenda 2030 (UN 2015). Instead, the SDGs are organised around 17 goals, 169 targets and more than 230 indicators that are intended

to represent a vision that is, in principle, compatible with strong sustainability. In p.4, UN (2015) envisions "[a] world in which consumption and production patterns and use of all natural resources – from air to land, from rivers, lakes and aquifers to oceans and seas – are sustainable". While the vision of the SDGs does broadly refer to sustainability conditions, in the absence of references to strong sustainability or natural capital, alignment with strong sustainability depends on what is being measured and whether it is maintained at an adequate level. For the latter, the SDGs have 169 targets, although many of them are not quantitative or cannot be easily measured (ICSU and ISSC 2015). In this line, Usubiaga-Liaño and Ekins (2021a) proposed two criteria to assess whether an indicator set represents the strong sustainability perspective. First, indicators of strong sustainability need to be related to the functions of natural capital, since strong sustainability requires the functions of natural capital to be maintained over time (Ekins et al. 2003). Second, the indicators need to have a sustainability reference values against which performance can be compared that reflects the conditions under which those functions are maintained. Based on these two criteria, Usubiaga-Liaño et al. (2024) reviewed four sets of SDG indicators used by international institutions. The results showed that 9-20% of the indicators focused on natural capital or its functions, with large variations between the indicator sets. However, more importantly, considering the topics represented in those indicators, 0-34% of them had a sustainability reference value depending on the indicator set. Consequently, the authors concluded that, as a general rule, the SDG indicators do not reflect environmental sustainability from a strong sustainability perspective, although meeting them could contribute towards it. This is more evident in that some governments rejected the possibility of formulating environmental targets around the notion of global environmental limits (Elder and Olsen 2019) and, therefore, this perspective was not integrated in the SDGs.

## Post-2020 Global Biodiversity Framework

The relevance of the SEEA in the context of ecosystem and biodiversity accounting was shown by Aichi target 2 in the last iteration of biodiversity goals, which required countries to integrate biodiversity into national accounting practices (CBD 2016). Nonetheless, since not all countries managed to do so (Secretariat of the Convention on Biological Diversity 2020), the same target was included in the SDGs as part of SDG 15 and in the GBF as part of target 14 (CBD 2022). Given the relevance of SEEA for ecosystem and biodiversity accounting, the statistical community has been included as a relevant stakeholder in the development and implementation of the GBF (Obst et al. 2020).

An assessment by UNEP-WCMC and UNSD (2019) found that, out of the 95 Aichi indicators considered, 34 showed full alignment with SEEA, meaning that the SEEA has the potential to provide all or most of the information required for their compilation. Another 37 indicators showed partial alignment with SEEA. More recently, UNDESA (2020a) referenced a different study to argue that, out of the 45 indicators provisionally chosen to monitor the GBF, 27 could be supported by SEEA. Currently, only two headline indicators on ecosystem extent and ecosystem services have been compiled, based on

SEEA guidelines (CBD 2024). Nonetheless, information from SEEA accounts is expected to support the monitoring of GBF additional targets and goals (Vallecillo et al. 2022).

As in the the SDGs, the GBF does not explicitly mention strong sustainability or critical natural capital, although its long-term vision is aligned with strong sustainability in that it seeks that “by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people" (CBD 2022, p.8). As in the previous case, the indicators provide more clues on the extent to which the framework can be used to monitor environmental sustainability. In this regard, the criteria proposed by Usubiaga-Liaño and Ekins (2021a) for the SDG indicators hold: i.e. that relevant biodiversity indicators need to be linked to the functions of natural capital and have an adequate reference value that reflects environmental sustainability conditions. Despite its broadness, biodiversity has been defined into a set of ‘essential variables’ including: (1) genetic composition, (2) species populations, (3) species traits, (4) community composition, (5) ecosystem structure and (6) ecosystem function (Pereira et al. 2013), with varying levels of conceptual clarity and data availability. These variables satisfy the first key part of strong sustainability by defining essentialness. They also align with most of the key targets of biodiversity monitoring in policy. However, despite the potential of these variables to provide reference values needed to retain their essentiality, such reference values have not been defined. Within the Planetary Boundaries framework, this is limited to extinction rates (Rockström et al. 2009), although further suggestions have been made to include biome integrity and levels of functional diversity (Mace et al. 2014). With these challenges of definitions of essential variables for biodiversity, it is no surprise that the monitoring frameworks lack sustainability references. Across all indicators of the GBF, only a few headline indicators make references to a standard to measure against (e.g. Red List Index, Red List of Ecosystems, fish stocks within biologically sustainable levels and species with effective population size), but quantitative reference values for sustainability conditions are not formulated in most cases.

## To which extent is strong sustainability embedded in the SDGs and in the GBF?

There are relevant overlaps between the SEEA on the one hand and the SDGs and GBF on the other in that several of the indicators used in the SDGs and GBF can be compiled in full or partial alignment with the SEEA. In practice, neither the SDGs nor the GBF mention weak or strong sustainability or critical natural capital in their official documents, as these frameworks did not explicitly consider these concepts. While their visions can be considered to be aligned with strong sustainability thinking, it is the indicator sets developed as part of those frameworks what describe the extent to which the SDGs and GBF embed strong sustainability in their monitoring processes. Recent research has shown the limitations of the SDG indicator to reflect compliance with environmental sustainability conditions (Usubiaga-Liaño et al. 2024). In the case of the GBF, many indicators do represent the state of natural capital, but, at this point, they do not reflect

whether environmental sustainability conditions are met. Instead, many indicators have to be interpreted in terms of whether the situation is improving or worsening.

## Integrating strong sustainability in the SEEA, the SDGs and the GBF

### SEEA as an entry point for strong sustainability thinking

Although so far policy applications are limited (Ruijs et al. 2019, Fairbrass et al. 2020), SEEA is expected to play an increasing role in natural capital accounting given its increasing adoption by national governments (Edens et al. 2022) and the availability of tools being developed to facilitate this process (Balbi et al. 2022). As an international statistical standard that is regularly revised and updated through a process led by the United Nations, SEEA is well placed to contribute not only to the SDGs and GBF, but also to future global accounting and indicator initiatives in the context of sustainable development and the environment.

While there is only a single reference to critical natural capital in the SEEA manuals, there are, however, more references to what could be construed as sustainability reference values, which are key elements of strong sustainability indicators. In particular, in the chapter on ecosystem condition accounts, the SEEA EA manual emphasises the need to define reference values that can be used to define high and low condition scores for a range of relevant variables. So far, the adoption of such reference values is not a widespread practice at the national scale, although relevant exceptions exist (Maes et al. 2020). This should be interpreted into a context in which ecosystem extent accounts are much more common than ecosystem condition accounts (Lange et al. 2022). Introducing reference values in policy frameworks, such as the GBF, SDGs and others, would provide an additional lens to interpret sustainability performance beyond the direction of progress. To this effect, various efforts, such as the essential biodiversity variables and essential ecosystem services variables (Balvanera et al. 2022), could provide useful indicators for which standards can be defined.

The use of reference values is not specific to the SEEA and can be found in other accounting and indicator initiatives. For instance, The Planetary Boundaries framework (Rockström et al. 2009) uses reference values to determine whether humanity is at risk of transgressing safe levels estimated for different Earth System processes. In a similar vein, the ESGAP framework (Usubiaga-Liaño and Ekins 2021a) proposes composite indicators that use reference values to identify whether the environmental functions of natural capital are threatened (Usubiaga-Liaño and Ekins 2021b, Usubiaga-Liaño and Ekins 2022). The Ecosystem Natural Capital Accounts developed for the Convention on Biological Diversity also proposes composite indicators, based on distance to targets, called ecosystem capital capabilities (Weber 2014) and recently other approaches that are aligned with SEEA and that consider the capacity of ecosystems to deliver ecosystem services have emerged, although additional work is needed to define reference values that describe sustainability conditions (Martini et al. 2024). Other composite indicators,

such as the Environmental Performance Index use established environmental policy targets as reference values to assess country performance (Wendling et al. 2020), while the Ecological Footprint uses the Earth's biocapacity as reference value to measure the unsustainable use of nature (Borucke et al. 2013). The use of reference values is also percolating into the field of Life Cycle Assessment and Input-Output Analysis to monitor the absolute environmental sustainability of products, companies and national consumption, but this is mainly done building on the Planetary Boundaries framework (Bjørn et al. 2020).

All in all, reference values represent the key item linking strong sustainability to the SEEA and the wider accounting and indicator initiatives.

## Reference values as the common element between SEEA and other relevant strong sustainability frameworks

Prior to the publication of the SEEA EA manual, there was no guidance on how to establish reference values for a diverse set of environmental issues. The SEEA EA manual did not only provide relevant definitions, but also described different approaches to select reference conditions and reference values.

As shown in Table 2, reference conditions for natural ecosystems can consider the features of ecosystems with minimal human influence, at a given point in time that represents the stable natural state, the best available condition of an ecosystem or the condition at a given recent year with comparable data. In semi-natural and anthropogenic ecosystems, the reference conditions can represent a given point in time that represents a stable socio-ecological state, the best available condition of an ecosystem, the condition at a given recent year with comparable data or the best condition attainable under good management practices. SEEA EA recommends using the natural state as the reference condition, although this is not always meaningful due to changes resulting from both human and natural processes. In other words, SEEA EA recommends using the 'optimal condition' to define reference values (Vallecillo et al. 2022).

The reference conditions shown in Table 2 can be assigned three different meanings (Vallecillo et al. 2022). First, they can represent the 'optimal condition', which relates to the concept of natural or undisturbed ecosystems. Secondly, 'sustainable condition' represents good environmental functioning, which is more permissive than the optimal condition in that ecosystems can be subject to some level of environmental pressure without jeopardising their integrity, stability and resilience. For instance, Jakobsson et al. (2021) considers sustainable condition to represent 60% of the value assigned to optimal conditions. In practice, ecosystem condition measured against optimal conditions reflects intrinsic values (value of nature), while sustainable conditions are closer to instrumental values (value of benefits provided by nature) (see Pascual et al. (2023) for an overview on values) that might or might not be aligned with policy targets (Keith et al. 2020). Lastly, reference values can represent a 'contemporary condition'. Given that the extent to which

contemporary conditions represent or not sustainable conditions might not be clear, its use is only recommended if there are no other alternatives.

Table 2.
Possible reference conditions to assess ecosystem condition.
Source: Adapted from UN (2021).

| Ecosystem | Possible reference conditions |
|---|---|
| Natural ecosystems | Undisturbed or minimally-disturbed condition |
| | Historical condition |
| | Least-disturbed condition |
| | Contemporary condition |
| Semi-natural and anthropogenic ecosystems | Historical condition |
| | Least-disturbed condition |
| | Contemporary condition |
| | Best-attainable condition |

Once reference conditions are defined, reference values need to be selected. As explained in hte SEEA EA manual, the latter represents the value of a variable at the reference condition, against which it is meaningful to monitor performance. As in the previous case, different methods exist (Table 3). The methods seek to identify reference values for minimally disturbed ecosystems (either through recent or historical data or through modelling), for least-disturbed conditions or best-attainable condition (based on statistical approaches of existing sites), through prescribed levels, based on concepts such as environmental limits, standards or targets or through expert opinion.

Assessments that incorporate reference conditions and reference values use a variety of methods to do so as shown in Table 4. The reader should note, that as explained above, not all the assessments of ecosystem condition incorporate such references. Some of the assessments included in the table use undisturbed or minimally-disturbed condition as the reference condition, others use contemporary conditions, while others use a combination of the two. In some cases, the use of the reference condition was not explicitly described in the text, so it had to be inferred by the authors. From the table, it seems that assessments that take a multi-ecosystem perspective tend to rely on a combination of methods, since there is limited value in using the pristine state as the reference condition in urban and agroecosystems. As for the reference values, not all condition variables used such values in all assessments. In some, such as Lof et al. (2019) and Vysna et al. (2021), several condition variables did not have reference values against which performance could be measured. Most of the remaining assessments used a variety of methods, prescribed levels being the most favoured one.

Table 3.

Available methods to estimate reference values.

Source: Adapted from UN (2021).

| Method | Description |
|---|---|
| Identification of reference sites | Reference values are defined based on the conditions of 'pristine' ecosystems with no or minimal human disturbance |
| Modelled reference conditions | Reference values are defined based on models that infer conditions in absence of human disturbance. |
| Statistical approaches based on ambient distributions | Reference values are defined based on the distribution of existing values for available sites. |
| Historical observations and palaeo-environmental data | Reference values are defined based on historical or palaeontological data. |
| Contemporary data | Reference values are defined based on a 'relatively' recent year for which data are available. |
| Prescribed levels | Reference values are defined based on concepts such as environmental limits, environmental standards or environmental policy targets. |
| Expert opinion | Reference values are defined by experts. |

## The role of strong sustainability indicator frameworks in promoting strong sustainability in SEEA

As mentioned above, there are two main conceptual frameworks that monitor environmental sustainability at the national and global levels through the use of science-based reference values of environmental sustainability (Rockström et al. 2009, Usubiaga-Liaño and Ekins 2021a), but the extent to which they could play a role in integrating strong sustainability in SEEA is unknown. For example, the Planetary Boundaries framework was designed to monitor environmental sustainability at the global level, while another framework, ESGAP, focuses on the national level. Although the Planetary Boundaries framework has been implemented at different geographical scales (Li et al. 2021), its use at the national scale has been inconsistent (Häyhä et al. 2016), which demands that more work is needed in defining context-specific local and national boundaries that are consistent with the global ones (Li et al. 2021) and some variables have been critiqued as being misaligned with sub-global scales (Mace et al. 2014). The ESGAP framework, on the other hand, operates at the national scale, which is the geographical scale at which most SEEA accounts are implemented. Thus, ESGAP is the only strong sustainability indicator framework that operates at the same scale as most SEEA accounts and that uses science-based environmental standards to monitor environmental sustainability. For this reason, there could be potential for ESGAP to reinforce the strong sustainability perspective in SEEA.

Environmental standards fall within the prescribed levels category formulated in SEEA (Table 3), which also considers other reference values such as policy targets. The latter are not necessarily aligned with the former (Usubiaga-Liaño and Ekins 2021a). When it

comes to reference conditions, environmental standards are intended to represent sustainable conditions, which, as argued before, differ from optimal conditions in that natural capital can be subjected to some pressure without losing its function. Arguably, the use of sustainable conditions increases policy applicability in that policy should seek to manage natural capital sustainably, at least in the long term. In its assessments, ESGAP promotes the use of science-based environmental standards exclusively to raise awareness about the sustainability gap. Except in the cases in which policy targets are equivalent to environmental standards, the use of policy targets is not recommended for determining sustainability. Using targets as reference values would yield the policy gap, a useful concept for policy, but one that falls short from environmental sustainability. While the use of sustainable conditions is preferred from a practical perspective, it might hinder comparability between countries in that setting environmental standards is a context-specific process. Although they are driven by their scientific rationale, value judgements are involved in how society deals with risk, uncertainty, irreversibility and threat of severe losses (Usubiaga-Liaño and Ekins 2021a). For this reason, on p.47, Keith et al. (2020) argue that "the scientific objectivity of the process needs careful consideration and the purpose of the condition assessment must be transparent and stated explicitly". For country comparison, using the optimal condition as reference, whenever possible, is more useful. Other approaches considered to define sustainable conditions as a numeric ratio of optimal conditions (Jakobsson et al. 2020, Jakobsson et al. 2021) are considered a very crude approximation, especially when environmental standards exist.

Table 4.

Approaches used to establish reference conditions and reference values in the literature.

Note: In some cases, the approaches used are mentioned explicitly in the references. In others, the content of the table shows the interpretation of the authors.

| Source | Scope | Reference condition | Reference values |
|---|---|---|---|
| Lof et al. (2019) | Urban, agricultural, water, natural and semi-natural ecosystems in the Netherlands | Undisturbed or minimally-disturbed condition<br>Contemporary condition | Identification of reference sites<br>Prescribed levels |
| Vysna et al. (2021) | Forest, agricultural and freshwater ecosystems in Europe | Contemporary condition | Prescribed levels |
| Jakobsson et al. (2020), Jakobsson et al. (2021) | Forest and alpine ecosystems in central Norway | Undisturbed or minimally-disturbed condition | Identification of reference sites<br>Modelled reference conditions<br>Statistical approaches based on ambient distributions<br>Prescribed levels<br>Expert opinion |

| Source | Scope | Reference condition | Reference values |
|---|---|---|---|
| Vallecillo et al. (2022) | Urban, agricultural, forest, wetland and other ecosystems in Europe | Undisturbed or minimally-disturbed condition<br>Contemporary condition | Identification of reference sites<br>Statistical approaches based on ambient distributions<br>Prescribed levels<br>Expert opinion |
| Tanács et al. (2022) | Major ecosystems in Hungary | Unclear | Prescribed levels<br>Expert opinion |
| Maes et al. (2023) | Forest ecosystems in Europe | Undisturbed or minimally-disturbed condition | Identification of reference sites |
| Parkhurst et al. (2024) | Abandoned farmland site in Australia | Undisturbed or minimally-disturbed condition | Identification of reference sites |
| Comte et al. (2025) | Marine ecosystems in France | Contemporary condition | Prescribed levels |

Thus, ESGAP provides a series of environmental standards across a series of relevant environmental variables that can be used for ecosystem condition assessments. In fact, there are already some overlaps between the environmental standards used in the European ESGAP case study (see Usubiaga-Liaño and Ekins (2021b)) and the prescribed levels used in some of the ecosystem condition assessments included in Table 4 (e.g. good ecological condition in freshwater systems or critical loads in terrestrial ecosystems).

Ecosystem condition assessments are still far from being consolidated. So far, only pilot studies exist, which are mostly restricted to European countries as shown in Table 4. As the field advances and assessments become more established and broader in their geographical and temporal scope, the information on environmental standards included in ESGAP assessments can be used as direct input. Focusing on sustainability rather than optimal condition leads to limitations of country assessments at the expense of increasing policy relevance. This was evident when developing ESGAP pilots in different countries (Comte et al. 2023, Otieno et al. 2021, Sato et al. 2024, Thang et al. 2021, Usubiaga-Liaño and Ekins 2021b) where the results could not be compared between them because not all the environmental standards used were the same. Nonetheless, by adapting the reference values to the country of study, ESGAP gains contextual relevance, particularly considering that no country comparisons are needed for the interpretation of the results.

The format in which the information is arranged in ecosystem condition accounts and ESGAP assessments differs, including the aggregation processes. For instance, ecosystem condition accounts are organised around ecosystems and the information is aggregated to provide a single score of condition by ecosystem type. On the other hand, in the ESGAP framework, the metrics are organised around the functions provided by natural capital and, consequently, the aggregated scores focus on those rather than on

ecosystems. Thus, while the same reference values can potentially be used, how these are integrated in the SEEA requires more careful reflection.

### The way forward for integrating reference values in the SDGs and GBF

Previously, we described how SEEA can contribute to the compilation of indicators used to monitor the SDGs and the GBF. As such, the influence of reinforcing the strong sustainability perspective in SEEA through reference values will be limited to the SEEA indicators incorporated into the SDGs and the GBF. However, beyond that, there is an opportunity to further integrate strong sustainability into these frameworks, especially when these are revised in the future.

In the case of the SDGs, there is an opportunity to further integrate reference values when the framework is revised to monitor sustainable development beyond 2030 as noted by Usubiaga-Liaño et al. (2024). In particular, the post-2030 sustainable development framework should increase the number of indicators that monitor the state of natural capital or the pressures to which it is subject and integrate as much as possible adequate reference values that can help interpret progress towards environmental sustainability (Fairbrass et al. 2024). It should also include explicit limits to consumption as this directly contradicts any hopes of sustainability if the use of resources is unrestricted.

In the context of biodiversity, which is also linked to some SDG indicators, efforts should be devoted to develop meaningful reference values, as these are currently lacking. There are, of course, major conceptual and practical challenges to this task (Hillebrand et al. 2023). By establishing adequate reference values, it will be possible to monitor progress beyond directionality.

## Conclusions

There is a need to promote strong sustainability in natural capital accounting to ensure that current trends of environmental degradation are adequately communicated to decision-makers. In this context, accompanying indicators with reference values can help change narratives that assign insufficient weight to the environment in economic and social policies.

The System of National Accounts and its environmental counterpart SEEA represent the main international statistical standards for integrating economic and environmental statistics. Thus, the latter is expected to play an increasingly important role in promoting the use of environmental data in the decision-making process. SEEA does not prescribe whether the weak or strong sustainability propositions should be prioritised. Instead, it allows both type of metrics to be calculated. In the case of strong sustainability, relevant metrics need to be able to describe whether the environmental functions of natural capital are under threat or not. To this end, relevant indicators need to embed adequate reference values that represent environmental sustainability conditions. The SEEA EA manual promotes the use of different sets of reference values to contextualise the

information from the ecosystem condition accounts, thereby representing the main contribution of the SEEA to strong sustainability thinking. There are different approaches that the SEEA EA recommends to estimate reference values, each of which is suited for different contexts. In order to assess environmental sustainability, environmental standards are needed, which fall within the 'prescribed levels' category of the SEEA.

Arguably, there are three main actions that could increase the presence of strong sustainability in SEEA and related assessments. First, the upcoming update of the SEEA Central Framework could make more explicit the potential of SEEA to calculate strong (and weak) sustainability indicators, while remaining neutral about the two (Femia et al. 2024). This should also be part of the revision of the thematic manuals. Second, the production of ecosystem condition accounts should be encouraged. So far, ecosystem extent accounts remain the main focus, but extent information needs to be complemented with the quality perspective provided by ecosystem condition accounts. Third, the integration of environmental standards in ecosystem condition accounts can increase the policy relevance of the resulting analysis, something that has been identified as a key limitation to bridge the science-policy divide. In order to advance in this area, further bridges can be built with other international initiatives, such as the SDGs or the GBF, which would also benefit from further integrating environmental standards. Frameworks such as the Planetary Boundaries or ESGAP, which rely on environmental standards or similar concepts, are useful in guiding the integration of environmental standards in SEEA and related indicator initiatives.

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## Author contributions

AU-L: Conceptualisation, Writing-original draft, Writing-reviewing and editing. OS: Writing-reviewing and editing. AC: Writing-reviewing and editing.

## Conflicts of interest

The authors have declared that no competing interests exist.

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