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The narrow application of the ecosystem services concept in EU policy

Jukka Kilgus^{1,2,3*}

*Correspondence:

Jukka Kilgus

Jukka.Kilgus@uvm.edu

¹Rubenstein School of Environment and Natural Resources, University of Vermont, 81 Carrigan Drive (Aiken 312), Burlington, VT 05405, USA

²Gund Institute for Environment, University of Vermont, 210 Colchester Avenue, Burlington, VT 05405, USA

³School of Sustainability, Leuphana University Lüneburg, Universitätsallee 1, 21335 Lüneburg, Germany

Abstract

The ecosystem services concept (ES), describing the benefits humans derive from nature, has gained prominence during the last decades. There is, however, only very little research on how the concept has been translated into policy, one of the core reasons for its establishment. To address this gap, the present study examines the extent and variety of the ES concept's usage in European Union policies since 2000. The study conducts qualitative content analysis of ten selected policy documents and background reports. The results show a rising, but typically 'narrow', use of the concept, which lacks depth in addressing critiques of ES approaches. This applies, in particular, to the underlying values and valuation methods. Here, the policies focus uniformly on instrumental values and monetary valuations, whereas other aspects, such as non-monetary valuations, are barely addressed. Apart from this, the contentiousness of the concept in the scientific literature is hardly recognisable in policy documents. These patterns are observable across the policies and background reports analysed and suggest either limited engagement due to formal constraints or a very particular and one-dimensional understanding of the concept by policymakers. Implications for future science-policy interactions in the field range from a call to increase the plurality of ES use to potentially adopting different concepts altogether, reflecting different societal paradigms for understanding human-nature relations.

Highlights

- This study investigates EU policies for their use of the ecosystem services concept.
- It finds that the usage has increased over the past 25 years.
- However, this seldom aligns with a more fundamental examination of the concept.
- This especially applies to underlying values, valuation methods, and controversies.
- There are two possible explanations: formal constraints in the policies or a very particular and narrow understanding of ecosystem services by policymakers.

Keywords Ecosystem services, Policy, European Union, Policy analysis



1 Introduction

1.1 Background

According to the *Millennium Ecosystem Assessment*, ecosystem services (ES) are defined as “the benefits people obtain from ecosystems” [1]. The concept was initially developed by ecologists as a communication tool to highlight nature’s value to humanity [2, 3]. Since about 30 years ago, the concept has gained popularity, driven by the works of Daily et al. [4], Costanza et al. [5], and many others.

ES are often linked to an instrumental view of human values towards nature (see, e.g., 6 or 2). This is because the concept assumes that nature, through ecosystems and biodiversity, performs specific functions that can be described as services, providing benefits and value [7]. Many efforts have been made to try to quantify these ES values (see, e.g., 5; 8). Such valuations are frequently carried out as monetary valuations. Various market methods, such as the market price method, the hedonic pricing method, or the travel cost method, are used to determine a dollar value that should reflect what the ES in question is worth [9]. This contrasts with intrinsic and relational understandings of values, where nature is regarded as having an intrinsic terminal value in itself [10] and where relationships between humans or human collectives and nature are considered essential in defining such values [11]. However, such non-monetary valuation methods have been much rarer. Examples are consultative methods such as (norm-based) surveys/questionnaires or in-depth interviews, and participatory approaches such as focus groups or citizen juries [12, 13].

The concept of ES, especially its monetary valuation, has been a persistent source of dispute and controversy within the scientific community since its inception. Criticism has emerged on several levels (for a more detailed overview, see 14 and 15): First, the underlying anthropocentric perspective, as well as the commodification of nature through the ES notion, have been criticised from an ethical standpoint (see, e.g., 16). This relates to voices suggesting that the ES concept is primarily based on Western worldviews and fails to incorporate a broader diversity of ontologies [17]. Second, the valuation of ES is said to be too focused on economic methods, which may not fully capture their value (16 and 18, as cited in 14). Here, some researchers also claim that methodological issues exist within those valuations [19]. At this level of application, there has also been criticism regarding a potential conflict of goals between ES and biodiversity protection [14, 16]. Third, from a scientific-theoretical perspective, the vagueness of definitions used within the discourse and the underlying normative assumption that all ecosystem outcomes are inherently “good” are criticised (16, as cited in 14). Finally, the communicative success has been assessed as limited [2], meaning that the notion has not had the intended impact of convincing people of the necessity of protecting nature, one of the main reasons for the establishment of the ES concept. Despite this criticism, during the last decades, the concept has gained popularity in science (see Fig. 1) and was also increasingly raised to the political agenda, helped by reports such as the *Millennium Ecosystem Assessment* [1], *The Economics of Ecosystems and Biodiversity* [20], and the *Dasgupta Report* [8].

1.2 Objectives and research questions

The present work analyses the adoption of ES and their valuation in the environmental policymaking of the European Union (EU) over the last 25 years, focusing specifically on

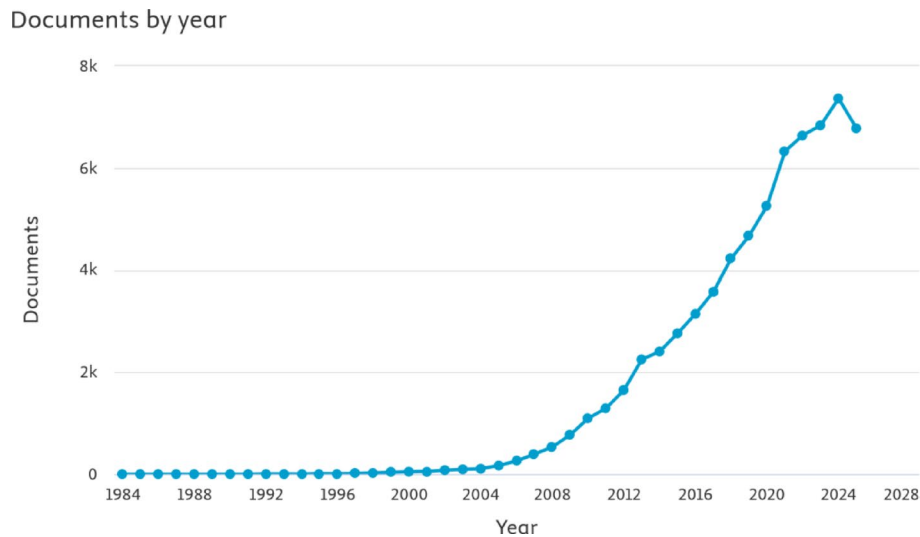


Fig. 1 Hits for the term "ecosystem service*" in title, abstract, or keywords, according to the scientific database Scopus (generated by Scopus in 11/2025)

the underlying values referred to and the methods used to assess and value them. The work will also investigate whether and how the policies address the criticism and controversies surrounding ES. Such a study appears relevant, as the ambition behind the ES concept was to raise the recognition of nature on the decision-making agenda. However, there is currently little evidence on the extent to which this has been successful. The case of the EU and its supranational policies was chosen as the EU plays a significant role in global agenda-setting and is considered by some to be a forerunner in the field of environmental regulation (see, e.g., 21). Also, there has been some previous research on ES in the EU [22, 23] to build upon.

The work aims to understand how ES and their valuations are integrated into the EU's policymaking. Special attention will be given to how their integration aligns with the critique raised about the notion. This analysis should help better understand the political adoption of the concept. It should indicate whether and how the controversies surrounding the topic are reflected in EU policy. This can be seen as embedded in the larger context of science-policy interactions. Research on such interactions is crucial for understanding the dynamics and challenges that arise when scientific concepts and ideas are translated into the policy arena. Questions like these are discussed in the fields of critical policy studies and science-policy interface research.

Respecting these goals, the study will try to explore the following research questions (RQs):

RQ1: How have ES and their valuations been integrated into EU policymaking?

RQ2: To what degree does the usage of ES reflect the scientific controversies around the concept?

RQ3: Are there patterns regarding the prominence and depth of engagement in the ES concept in policy documents, particularly concerning underlying values, valuations, and controversies?

In contrast to Bouwma et al. [24], who published a similar study seven years ago, the focus of the present work is less on the coherence of the concept's integration than on

the development of ES adoption over the past 25 years and on how criticism and controversies around the notion are becoming evident in policies. Besides that, their study analysed policies only up to 2014, whereas the present work draws on a much larger, more up-to-date sample.

2 Methods

2.1 An approach to policy analysis

Policy analysis, in general, can be considered a methodological umbrella term describing a diverse set of particular methods by which researchers try to understand “how and why governments enact certain policies and their effects” [25]. This work pursues an interpretive approach to policy analysis, employing the following methodological procedure: First, an overview of the relevant policies was created, accompanied by a brief quantitative analysis of the term’s use in the documents over time (2.2). Next, there was a more in-depth look into a selected set of key policies, analysing them qualitatively and with particular attention to the RQs (2.3). In the third and final part, the results from the literature review and the policy analysis were synthesised (2.4), which led to the discussion. In this discussion, the results were interpreted using theoretical frameworks from science-policy interface studies. This was done to better understand the successes and challenges of transferring and communicating the ES concept into policy. To establish a normative reference point for this interpretation, an ideal–typical adoption of the ES concept by policymakers is outlined, against which the actual adoption observed in the policy analysis is compared.

2.2 Policy collection and overview

In this first part, the analysis focuses on where and how often the ES concept is mentioned in EU policy documents and how this has evolved over the past 25 years. Using the Eur-LEX database (a database containing all official policy documents issued by the European Commission, European Parliament, and Council of the EU), all documents containing “ecosystem service*” as a term ($N = 190$) were extracted. This was done on January 6th, 2024. “Ecosystem service(s)” is here considered as a term of art, which is why no other similar notions like “natural service(s)” or “environmental service(s)” were included. The resulting list of policies was then sorted according to how often they mention ES. This limited quantitative part can thus be seen as a preparation for the following qualitative analysis.

2.3 Qualitative content analysis

2.3.1 Selecting the policies and additional reports

In the second part of the policy analysis, seven policies were selected for in-depth analysis. Here, the aim was to learn how they engage with the concept and how it contributes to the policy’s objectives. For this, the documents must provide sufficient grounds for analysis, so that, in the preselection, only policies that mentioned ES more than 10 times were considered ($N = 21$). Of these, six were excluded because they only mentioned ES in the footnotes or because they were duplicates, such as when there were several versions of a policy, resulting in a sample size of $N = 15$ from the original 190 documents. Another point of interest lies in the development of the term’s use over time, which is why the selected policies should ideally span as wide a period as possible. Finally, an attempt was

made to include different types of policy documents (regulations, decisions, directives, and communications), as each serves a distinct purpose and allows for consideration of the diversity of the institutional bodies issuing them. Considering these guidelines, the final selection resulted in seven policies (N = 7) deemed manageable within the scope of this work.

In addition to the selected policies, three key background reports were incorporated into the analysis to extend the data foundation and compare the results from the policies with those from a different type of document. These reports, explicitly published to support legislation and frequently cited in the policies at hand, are not bound by legal formulas and, because of their scientific foundation, were expected to offer more profound insights into how ES are understood in the broader policy arena. The selected policies, along with the background reports, are listed and numbered in Table 1.

2.3.2 Constructing a coding scheme

The qualitative content analysis was conducted with the software MaxQDA 2022 and set up as a mixture of the approaches of Hecker et al. [36] and Hall & Steiner [37]. In the first step, a draft for a coding scheme was constructed deductively, allowing for coding text passages in the documents concerning the RQs. This scheme was set up to account for the already described underlying values (intrinsic, instruments, relational), forms of valuation (monetary—subdivided into direct, indirect, and non-market methods; non-monetary; unspecified), and controversies around the concept (too anthropocentric, commodification of nature, focus on Western worldview, focus on economic valuations, valuation problems, conflicts with biodiversity, vagueness of definitions, normative concept, no success as communication strategy). During the initial reading of text passages

Table 1 Policies and background reports under consideration for qualitative analysis

No	Titel (Reference)	Own abbreviation	Type (Code/CELEX)	Pages	Mentions
1	Halting the loss of biodiversity by 2010—and beyond—Sustaining ecosystem services for human well-being [26]	Halting loss of biodiversity	Communication (COM/2006/0216 final)	15	17
2	Our life insurance, our natural capital: an EU biodiversity strategy to 2020 [27]	Biodiversity strategy	Communication (COM/2011/0244 final)	17	23
3	Living well, within the limits of our planet [28]	Living well	Decision (32013D1386)	30	17
4	Prevention and management of the introduction and spread of invasive alien species [29]	Invasive alien species	Regulation (32014R1143)	21	14
5	LIFE multiannual work programme for 2018–2020 [30]	LIFE	EC Implementing decision (C/2018/0686)	69	11
6	New EU Forest Strategy for 2030 [31]	Forest strategy	Communication (COM/2021/572 final)	28	22
7	Horizon Europe—the Framework Programme for Research and Innovation and its financing [32]	Horizon (Anx. 9 = 7.1; Anx. 12 = 7.2)	EC Implementing decision (C/2023/2178 final)	769	159
8	OECD Environmental Outlook to 2050 [33]*	OECD report	Background report	353	53
9	Mapping and Assessment of Ecosystems and their Services [34]	MAES	Background report	138	280
10	Accounting for Ecosystems and their Services in the European Union [35]	INCA	Background report	62	208

*Acknowledge that the OECD report goes far beyond the EU and includes other countries, too. It is, however, still a relevant background report as it informs EU policy

on ES in the first policies, a few code categories were added inductively: the current state, the protection, the different types of ES, and payments for ecosystem services (PES).

2.3.3 Coding the documents

After the coding scheme was established, the policies were coded in chronological order, starting with the first one to be published (*Halting Loss of Biodiversity*) and proceeding to the latest (*Horizon*). The initial plan was to read and code all text passages containing the term “ecosystem service” or “service” in general, and the paragraphs before and after. However, for the policies in which ES played a significant role throughout the document (*Halting Loss of Biodiversity*, *Biodiversity Strategy*, *Living Well*, *Invasive Alien Species*, *Forest Strategy*), it was more convenient to read them in their entirety, line by line, to avoid missing anything. The original plan was retained for the other policies, in which the concept was used only sporadically or in specific parts of the text (*LIFE*, *Horizon*). In general, the coding referred only to parts of the text that explicitly discussed ES. Several other text passages also referred to, for example, environmental costs or, more generally, the economic aspects of environmental legislation, which were essentially not included in this analysis. Only for passages using “natural capital” were rare exceptions made if it was becoming evident in a document that the two terms were used interchangeably.

To ensure the quality and reduce the subjectivity of the coding process, the consensual coding method was applied [38]. Here, different researchers independently code the text, and the results are subsequently compared using the MaxQDA function “intercoder agreement”. This “control coding” was conducted by a colleague for the policy “Halting Loss of Biodiversity” and yielded an agreement of 86.15%, which can be considered very good (ibid., p. 210).

After coding the policies, the results were analysed step-by-step, considering general observations, similarities and differences between policies, and specific examples concerning the special areas of interest outlined above.

2.4 Synthesis

The results obtained from the policy analysis were then interpreted in light of the literature review conducted beforehand. Special attention was paid to how the policies and background reports under consideration frame ES, how deeply they delve into the concept, its underlying values, and forms of valuation, and whether and how they incorporate existing controversies around the topic.

2.5 Normativity & limitations of the study

The study, by default, is limited to the scope of policies within the EU, which is undoubtedly not generalisable to other governance bodies due to the extraordinary supranational constitution of the EU, the (relatively) high economic standard of most of its member states, and its perceived and self-assigned role as an environmental forerunner. Therefore, if further research were conducted to expand this analysis to national policies across EU member states and beyond, it might yield valuable insights. Besides this, policies generally have specific goals and use a very particular language, which also impacts the analysis results. The methodological design is limited by the predefined scope of policies, which underwent deeper qualitative investigation, mainly selected based on their frequency of mentioning the concept. Although there are certainly policies with fewer

mentions of the term that might still provide valuable insights, the limited capacities for the work required some preselection, for which the number of mentions, combined with the type of policy and the year of publication, proved to be very convenient. Apart from this, qualitative document analysis is often just one part of a comprehensive policy analysis. The methodology of the present work, however, focuses entirely on document analysis, which may lead to relevant aspects being overlooked. Apart from this, ES can already be seen as a normative concept, as it assumes a certain ethical starting point. A work dealing with ES must acknowledge that this concept, like every other model, does not provide an objective description of reality but a specific heuristic approach.

3 Results

3.1 General analysis

3.1.1 Overview of policies

In the 190 policy documents initially considered, the term “ecosystem service*” appears between 1 and 159 times per document. More than half of the policies are communications from the EC (97 out of 190), while the rest comprise regulations (56), decisions (29), and directives (8). Figure 2 shows the number of policy documents mentioning ES yearly since its first appearance in an EU policy document in 2000.

On average, a gradual increase in the use of the concept can be observed over the past 25 years, especially in legally binding regulations. The most significant usage occurred from 2021 to 2023, with more than 20 documents per year mentioning ES. Over time, the use of ES in EU policy documents has shifted from communications to regulations, decisions, and directives. Several terms are often used in a similar context or as synonyms for ES, even when this is not scientifically accurate. A notion that almost always appears alongside ES (in 185 of 190 policies) is “biodiversity,” which is mentioned in 1206 documents overall. “Ecology” appears in 232 documents, of which 24 also mention ES. A similar overlap (26) is observed with “environmental service*,” which appears in 147 policies. Caution is needed here, as the term sounds almost identical to “ecosystem services.” Still, it is often used in a very different sense to describe economic services offered by firms that relate in some way to the environment. Another term is “natural capital,” which appears in 129 documents, with an overlap of 65 with documents that use ES.

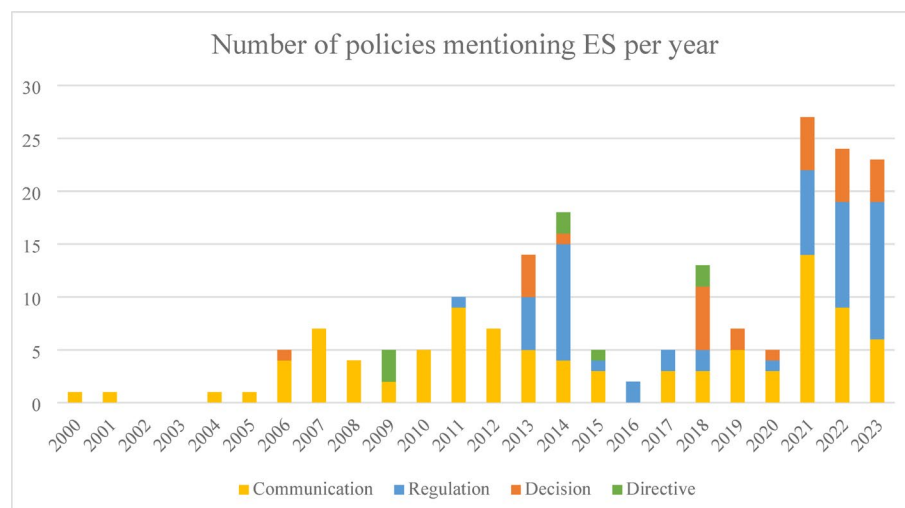


Fig. 2 EU policy documents mentioning ES since 2000 (own graphic based on Eur-LEX)

Document name	1 Halting Loss of Biodiversity	2 Biodiversity Strategy	3 Living Well	4 Invasive Alien Species	5 LIFE	6 Forest Strategy	7.1 Horizon Anx. 9	7.2 Horizon Anx. 12
1 Halting Loss of Biodiversity	1,00	0,89	0,87	0,84	0,82	0,84	0,82	0,84
2 Biodiversity Strategy	0,89	1,00	0,87	0,79	0,87	0,89	0,92	0,79
3 Living Well	0,87	0,87	1,00	0,87	0,84	0,87	0,84	0,82
4 Invasive Alien Species	0,84	0,79	0,87	1,00	0,76	0,79	0,76	0,89
5 LIFE	0,82	0,87	0,84	0,76	1,00	0,97	0,89	0,82
6 Forest Strategy	0,84	0,89	0,87	0,79	0,97	1,00	0,92	0,84
7.1 Horizon Anx. 9	0,82	0,92	0,84	0,76	0,89	0,92	1,00	0,82
7.2 Horizon Anx. 12	0,84	0,79	0,82	0,89	0,82	0,84	0,82	1,00

Fig. 3 Similarity matrix of policies under consideration (generated by MaxQDA)

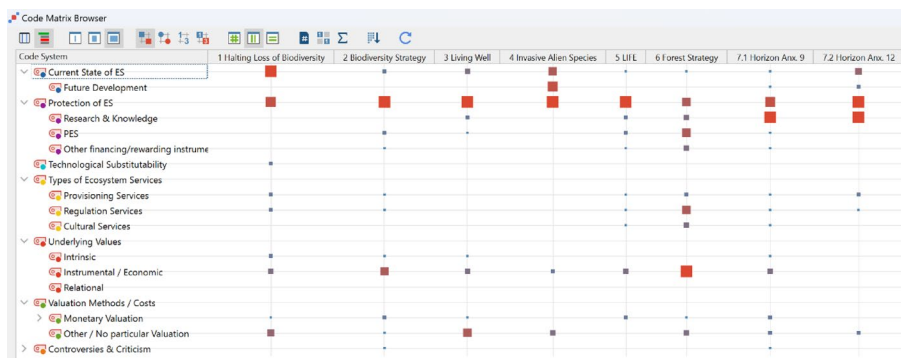


Fig. 4 Which category appears most often in the policies?—code matrix browser by column (generated by MaxQDA)

According to common understanding, this is probably the term most closely associated with ES. Other similar terms like “nature’s service*” (0 hits) or “Nature’s Contribution to People” (2 hits), in contrast, barely appear.

3.1.2 Policies for in-depth analysis

The analysis of the policies under review reveals that they understand and utilise the concept similarly, although it is more central to some policies than others. The code patterns across the policies are comparable, as shown by the results of the Similarity Analysis Tool in Fig. 3. This tool displays the overall overlap in coding across documents, in terms of code occurrences and frequencies. All values are above 75%, with 12 out of 28 exceeding 85%, indicating fairly consistent patterns.

3.2 Current state, protection, and types of ES

3.2.1 Policies

ES are often discussed in relation to their current state and protection. The Code-Matrix-Browser provides an overview that shows which policy most frequently includes a specific code, as illustrated in Fig. 4. For nearly all policies (excluding the *Forest Strategy*), the current state and protection of ES are the most commonly used codes: 4 × Protection, 2 × Research & Knowledge, 1 × Current State. However, the connection to the underlying concept of ES remains limited in these parts of the policies.

Concerning the current and future state of ES, the policies often depict ES as “in decline” [1:3; 7.1:100 – i.e., document 7.1 (*Horizon Anx. 9*), page 100], in “degradation” [2:5; 3:3], or under “threat” [4:1; 7.1:227]. Even though these attributions can be backed

scientifically [39], some policies highlight that we still do not fully understand ES and that there is insufficient knowledge about the issue [e.g., 7.1:64]. Regarding public awareness of the problematic state of ES, the oldest policy under consideration (Halting Loss of Biodiversity) emphasises that there is increasing public attention to the issue (this policy was published in 2006).

Moving to the protection of ES, many policies generally talk about ES having to be “maintained” [e.g., 2:6; 3:11], “restored” [e.g., 1:11; 2:3; 3:2], “conserved” [e.g., 1:11; 3:4], “enhanced” [e.g., 2:6; 3:4; 5:48], “protected” [e.g., 2:5; 6:13; 7.1:18] and their support, governance, and knowledge “strengthened” [1:12–13; 7.1:436]. These claims are often presented in this manner without further explanation. In the *Invasive Alien Species* policy, it is framed as “adverse impact on [...] ecosystem services are minimised” [4:8]. In *LIFE*, a similar pattern can be observed, according to which the “conditions” of ES should be “improved” [5:20]. In *Halting Loss of Biodiversity*, this is justified, among other things, with the limited technological substitutability of ES [1:4–5]. One significant component of protecting ES is said to be strengthening knowledge of the concept. In some policies, especially in the appendices of *Horizon*, this is addressed in greater detail, which is reasonable because *Horizon* is the critical programme for funding science in the EU [40]. Prominent examples of how this strengthening of knowledge should work in practice are through better mapping and assessing ES [3:21; 5:23]. In the *Forest Strategy*, these research-centred approaches are extended to explicitly imparting the associated knowledge and skills to the people behind ES, such as foresters and conservationists [6:10]. This strategy also discusses developing greater knowledge of agroforestry and PES, which can be identified as protection tools targeted by the policies. PES are proposed and presented as possible solutions to ES protection in the *Biodiversity Strategy*, *Living Well*, *LIFE*, *Forest Strategy*, and *Horizon Anx.* 9. In the *Forest Strategy*, this instrument is quite intensively covered with examples of its implementation [6:17]. Additionally, the policy discusses the EU’s willingness to support the establishment of such schemes in the future. Other economic instruments proposed to protect ES are the Natural Capital Financing Facility [3:47] and the Carbon Farming Initiative [6:19]. Despite this, the policies often remain broad and unspecific regarding particular economic instruments, apart from PES (*Biodiversity Strategy*, *Horizon Anx.* 9).

When analysing the use of different types of ES, it becomes apparent that most policies only briefly introduce provisioning, regulating, or cultural services. *Living Well* and *Invasive Alien Species* do not even mention them at all. Across the policies, there is a focus on provisioning and regulating services, with cultural services being discussed less frequently. Supporting services are not explicitly addressed in any policy document.

3.2.2 Background reports

In the reports consulted for in-depth analysis, there are not many new insights to be derived regarding the current state and protection of ES, as the policies themselves already cover these categories extensively. Notably, *MAES* and *INCA* discuss the current state of ES and its protection in detail. Regarding the different types of ES, the analysis finds that regulatory ES are referred to most often across all three background reports. Provisioning services play a similarly prominent role, while cultural services remain vastly underrepresented. This is particularly true of the *OECD report*, in which they are not discussed at all. Notwithstanding, as this analysis should focus on the underlying

values, valuations, and covered controversies, it will not delve into further detail here. The only notable difference to the policies is a closer presentation of what ES actually are.

3.3 Underlying values

3.3.1 Policies

As already established in the introduction, the underlying ethics of the ES concept typically relate to the instrumental values humans assign to nature. Still, for this work, it appears relevant to examine whether different values are also raised regarding ES, as the instrumentalisation and commodification of nature are key points of critique. After revising and analysing the policies, the presumption that mainly instrumental values are cited when discussing ES and human-nature relations in a broader sense can be confirmed. In four policies, intrinsic values are raised, but other forms of value, such as relational values, are not found at all. Instrumental values become apparent 52 times across all policies, except *Horizon Ann. 12*. Partly, the framing is rather general in terms of how instrumental values are understood (“providing benefits for present and future generations” [1:4]), and partly, it is a bit more particular (“underpin EU growth, jobs, and wellbeing” [1:4]). Often, these mentions are interlinked with terms related to economic growth and social concepts such as well-being and health. Here, economic growth and social well-being are frequently depicted as essentially the same (e.g., “essential contribution [of ES] to human well-being and economic prosperity” [2:3; 3:7] and “social and economic value” [6:20]). Instrumental understandings of value are often linked to examples of provisioning (and regulating) ES. The few times intrinsic values come up (6 times), it is nearly always in the following way: “[I]n addition to its intrinsic value, biodiversity and the services it provides have a significant economic value” [2:3]. Only *Halting Loss of Biodiversity* goes into greater detail on the ethical view of intrinsic motivations, arguing that humans “do not have the right to decide the fate of nature” [1:4]. In contrast to instrumental values, when intrinsic values are mentioned, they are often associated with cultural services.

3.3.2 Background reports

The background reports reveal a striking similarity in the domination of instrumental values. Here, the framing that ES “underpin our economies and our well-being” [10:10] is also evident. While *MAES* barely discusses underlying values in greater depth, *INCA* has a particularly strong focus on instrumental values, often referring to ES as beneficial for the economy [e.g., 10:9; 10:13; 10:48]. The *OECD report* partly goes beyond this, and, while still focusing on the instrumental nature of ES value, shows a more nuanced understanding of the concept. This can be seen, for example, by the increased emphasis on the contribution to well-being (as compared to the economy) [8:137; 8:186] and a less anthropocentric approach to ES, which includes the natural environment as a beneficiary of ES, not just people [8:35]. However, across all 553 pages of the three reports, there is only one vague reference to intrinsic values: “benefits individuals derive from the knowledge that biodiversity exists” [8:162]. Even this mention relates to non-use values, such as existence and bequest values, which might be framed as intrinsic values but are essentially instrumental (they still involve deriving a benefit for humans).

3.4 Forms of valuation

3.4.1 Policies

Nearly all policies incorporate monetary valuations (apart from *Invasive Alien Species* and *Horizon Anx. 12*), in contrast to only one of them talking explicitly about non-monetary valuations (*Horizon Anx. 9*). This is a similar pattern to the one observed for instrumental and intrinsic values and underlines the predominant position of monetisation in ES valuation. Half of the policies that assign monetary valuations to ES place a more or less explicit price estimate on ES, ranging from “in the order of hundreds of billions of Euros per year” [1:4] to “economic losses of over EUR 300 billion” [3:7]. This is typically expressed in terms of losses due to ES degradation in the EU, but sometimes the monetary value of a particular ES is presented [e.g., pollination in 2:4]. In *Horizon Anx. 9*, the authors discuss “natural capital accounting” [7.1:46], an essential tool for making monetary valuation accessible to decision-makers, such as in *INCA*. Regarding the explicit valuation method and its derivation, the policies rarely provide details and, in some cases, do not even cite sources [1:4; 2:7]. Quite often, documents vaguely refer to other kinds of valuations or high/low values without specifying what they mean by these terms (also without specifying whether they refer to monetary or non-monetary valuations). Examples of this are “high-nature-value farmland” in *Halting Loss of Biodiversity* [1:5; 1:11; 1:14] or “high ecological/biodiversity value” in the *Forest Strategy* [6:6; 6:12]. Another example being discussed is the “costs” of a particular measure, as well as the costs of ES degradation [e.g., 1:14; 3:22; 7.1:46]. Although that does not clearly refer to monetary value, this is probably meant when referring to “costs”. The only time “non-monetary valuation” is explicitly raised is in *Horizon Anx. 9* [7.1:97–98], where the focus is on improving knowledge of valuation (both monetary and non-monetary). After all, even here, this stays rather vague.

3.4.2 Background reports

Regarding valuation methods and approaches, the background reports provide a much stronger basis for analysis than the policies. Similar to the policies, the primary focus is on monetary valuations (59 mentions) rather than non-monetary valuations (6 mentions). Still, they are covered in considerably more detail. Especially in the *OECD report* and in *INCA*, monetary valuation is framed as something highly positive that should be expanded to improve knowledge and governance [e.g., 8:30; 8:193; 10:28]. An exemplary description for the understanding of ES valuations and accounting is the following: “Ecosystem service accounts estimate and track these flows or quantities that our society is using from nature as if it were transactions between two economic sectors” [10:10]. In contrast to the policies, particularly *INCA* (and partly the *OECD report*) goes into more detail concerning the classification of valuation methods. This approach also makes sense here, as *INCA*'s primary objective is to comprehensively account for ES in EU countries. The report examines seven ES [10:10] and estimates their total economic value. This value is measured as “EUR 234 billion in EU28 in 2019” [10:42]. In addition, it outlines the valuation methods for four of these ES in more detail, all of which fall under direct market methods. For crop provision and carbon sequestration services, the market values for crops [10:32] and, respectively, for carbon [10:40] are used, reflecting the market price method. For flood control and water purification, the cost-based method is employed, estimating the monetary value of avoided damage (for flood control [10:34])

or the replacement cost of the service (for water purification [10:38]). One passage claims that non-market valuation methods offer a solution to the problem that “most ecosystem services are not tradable on markets” [10:28]. However, the example given afterward is the travel cost method, which is not a non-market valuation method but an indirect market method, according to *MAES*. Non-monetary valuation is mainly discussed in terms of indicators in physical units [e.g., 10:10; 10:28], which are seen as a tendentially intermediate step before they “can be translated to monetary units (euro)” [10:28]. This means there is no closer examination of non-monetary valuations as an alternative to monetary ones. The reason given for such a preference for monetary units is their comparability and the possibility of aggregating different services from various ES [10:28].

3.5 Controversies and criticism

3.5.1 Policies

In the introduction to this article, an overview of the controversies surrounding the ES concept is provided, which are numerous and prevalent in the scientific discourse. Nevertheless, the policies under consideration contained hardly anything regarding controversies or criticism. Only two policies briefly mention “valuation problems” at one point [2:2; 7.1:100] without further elaboration. Later, both continue to use monetary valuations, despite the caveats expressed earlier.

3.5.2 Background reports

In the background reports under review, three types of controversies are identified: potential conflicts between ES and biodiversity, valuation issues, and the vagueness of definitions. Since the latter two topics are closely related, they will be combined in this section.

Regarding potential conflicts with biodiversity, two of the three documents warn that “trade-offs” exist between ES and ecosystem condition [9:10; 9:57] or between ES and biodiversity [10:39]. However, these trade-offs are not elaborated further, apart from calling for more research. The *OECD report* elaborates on this by stating that demand for ES “places considerable pressure on biodiversity” [8:178]. The issues surrounding valuation difficulties and the vagueness of definitions are addressed in a dedicated paragraph in *MAES* [9:12–13]. Quantification challenges are particularly highlighted for cultural services [also 9:28], including reliance on data sources and issues related to upscaling. The report also notes a bias towards provisioning services and the availability of information [9:57], which results in specific ES, such as those without indicators, being largely overlooked in common assessments. Conversely, *INCA* emphasises the uncertainty associated with monetary estimates and advocates for cautious interpretation of such figures [10:28; 10:49], a critique often echoed in scientific literature [41]. Finally, the *OECD report* describes ES as “invaluable” [8:161], recognising the difficulty of assigning a precise monetary value to nature. Nevertheless, a few sentences later, the authors list monetary values for ES, which reveals inconsistencies and ambiguity in their statements.

4 Discussion

4.1 Synthesis of results

The study revealed an increasing use of the ES concept in EU policy over the past 25 years, particularly from 2000 to 2014 and again since 2020. Concerning RQ1, which asks how ES and their valuations have been integrated into EU policy, the documents under in-depth analysis show a relatively extensive and homogeneous use of the notion of ES. However, the concept is often employed without a clear definition or detailed explanation and is frequently used interchangeably with “biodiversity” (e.g., “biodiversity and related ecosystem services” in Halting Loss of Biodiversity, and similarly in *Invasive Alien Species*). This makes it appear to be often used as a buzzword, especially as policies frequently speak of “increasing” or “enhancing” ES or the knowledge about it, without specifying how this should be done. This superficial engagement with the concept is also evident in the absence of notes on the underlying ethical values and diverse forms of valuation, a consistent pattern across all considered policies, as was the core inquiry behind RQ3. Instrumental values and monetary valuations are seen as the norm, and other values and different types of (non-monetary) valuation methods are marginalised. A similar pattern can be observed regarding the integration of controversies and the contentious nature of the concept, which were the focus of RQ2. The extent to which these are reflected in the policies’ use of ES remains limited, and they hardly find a place.

In contrast, an ideal–typical approach to the uptake of ES in policy formulation would acknowledge the diversity of discussions surrounding ES and incorporate a broader range of values and valuations. More explicitly, it could involve a balanced application of monetary and non-monetary valuation methods when advocating for the protection of ES. Additionally, policies could at least highlight that humans value nature not solely for instrumental reasons [11, 42] and that ES do not just provide benefits to humans but also to the larger biotic community [43]. Even if the reflection of these points were only marginally emphasised in the policies, it would still demonstrate engagement with the ES concept in its diversity and recognition of the ambiguities and controversies. This, in turn, could influence future decision-making, for instance, by encouraging individuals and organisations to think beyond monetary values in conservation.

The background reports offer, for obvious reasons, greater depth in the application of ES, especially with specific examples of services and particular valuation methods. Still, intrinsic or relational values, non-monetary valuations, and controversies surrounding the concept are only raised sporadically. This reveals a notable trend across the examined reports and policies.

4.2 Two explanations

The analysis results reveal a clear lack of transfer between the diverse scientific discourse and policy documents and background reports. This is particularly true regarding the extent to which the ES concept is understood, particularly in terms of its contentiousness. For this, two different explanations can be given: the first is that focusing on numbers and solutions in policy is to be expected. Policies are different from scientific discussions and must follow a specific problem–solution structure. It means they must be concise, and there is usually insufficient space for broader theoretical discussions. This argument is supported by the fact that the analysed policies show a relatively homogenous use of the notion, albeit they differ in form, purpose, and the issuing

authority behind them. Following these assumptions, the analysis results would not be surprising. The background reports show a very similar, homogeneous use of the notion, even though sometimes a little more nuance emerges (e.g., when acknowledging trade-offs between ES provision and biodiversity protection [8:178]). The second explanation is that policymakers and their advisory bodies have a very narrow understanding of ES and may even be ignorant of the controversies surrounding the concept. Such an argument is further supported by analyses of background reports, which are crucial to policy outcomes. These reports also primarily focus on instrumental values and monetary valuations, while neglecting controversies. The claim that there is insufficient space to address these issues and the concept's plurality cannot be taken seriously in this context. However, policies often prioritise economic and monetary arguments, and especially environmental policies might need to use such terms and arguments to demonstrate their relevance. This suggests that environmental governance in the EU heavily depends on economic arguments, particularly when there are potential conflicts over priorities and budget allocation with other policy areas. Such an 'asset-management' approach to environmental governance has been heavily criticised. [44, 45].

Both policies and additional documents build upon the more quantitative and less critical part of the scientific discourse. The analysis also supports the critique that policies prioritise provisioning and regulating services while marginalising supporting and cultural services, which are harder to quantify [9:57]. It is impossible to determine which of the two explanations is correct. It seems likely that the truth lies somewhere in between, with both the limited capacities within the documents and a relatively narrow understanding of the concept playing a role. Notably, however, both possible reasons are considered here.

4.3 Lens from science-policy interface

If we aim to broaden our perspective and draw conclusions for the larger science-policy interface, it seems essential to embed the findings into a broader theoretical framework. Such frameworks help understand and interpret how scientific knowledge is transferred into the policy sphere.

Researchers such as Sheila Jasanoff argue that this transfer from science to policy is never linear; instead, there is a contested nature of knowledge production and use [46]. We notice this in the difference between the scientific discussion of ES on the one hand and how the concept is used in policy documents and background reports on the other. The scientific debate on ES, as we have seen, is very diverse and, in some cases, critical of the ES concept itself, but even more so of its commercialisation and the use of monetary valuation methods. However, this study shows that the adoption of ES in EU policy is occurring in a highly homogeneous and uncritical manner, failing to recognise the contentious nature of the idea and instead treating nature as a commodity and a set of metrics. This indicates that ES are selectively understood and altered by policymakers – a common occurrence at the science-policy interface [47].

Another crucial notion in theoretical discussions on the science-policy interface is the character of a "boundary object" [48, 49]. A boundary object is understood as a concept that can be interpreted differently by scientists and policymakers while keeping a shared meaning [48]. In the past, researchers have already presented ES as a potential boundary object for sustainability in general [50] but also more explicitly for the interplay

between science and society regarding social-ecological systems [51]. The present analysis of policies confirms the character of the boundary object, in that there are different interpretations, not just between scientists and policymakers, but also among scientists themselves. This becomes particularly obvious when comparing the background reports, which focus on instrumental values and monetary valuations, with the often critical parts of the broader scientific discourse. While boundary objects can certainly be considered important for advancing science-policy interfaces and translating scientific concepts and findings into policy, the observed disparity highlights the potentially complex character of boundary objects, particularly when interpretations by different actors diverge too far from one another.

From a science-policy interface perspective, the relationship between the ES concept and the concept of Nature's Contributions to People (NCP) deserves particular attention. NCP has been raised on the scientific agenda by the IPBES in recent years and is the subject of a growing number of publications. One could make the case that the shift from ES to NCP shows a changing paradigm in science (and maybe also in society), moving away from Mace's "nature for people" towards "nature with people" [52]. Maybe ES was a good concept when the former paradigm was predominant. Now that the discourse is moving beyond instrumental values, however, it may no longer be fitting and might be replaced by new concepts. One could view this as an indication of the gradual saturation of the ES literature since 2021, as shown in Fig. 1. The abundant criticism the concept has received might also be a sign of a likely decline. Despite this criticism, the vast majority of literature on ES valuation concentrates on monetary methods, which also makes it unsurprising that market-based instruments such as PES are dominating ES policies (see also 53). It will be challenging to overcome this dominance, especially as there are certainly (power) interests linked to the current status quo and its monetisation of nature [44]. Overall, it will be interesting to observe how the notions of ES and NCP continue to evolve in both the scientific and policy discourse.

4.4 Implications for future science-policy interactions

Based on these findings and their potential interpretations, three implications stand out for future science-policy interactions in the field of ES, with a particular focus on the EU.

First, one should recognise the tension field in which policies operate, between partly acknowledging ES as "invaluable" [8:61] and still being willing to produce numbers to support governance and decision-making. As already demonstrated, this decision-making feasibility was a critical motivation for developing the concept and its associated valuations. Anyone who now criticises the one-dimensionality of the political use of ES has every right to do so, of course, but should be aware that being able to put quantitative and comparable values on nature was one of the intentions of the concept from the outset. To harmonise this field of tension, it could be argued that a right balance is needed and that case-by-case decisions are necessary to determine when, for example, a monetary valuation can be considered useful [54, 55]. The same goes for the appropriateness of PES in a given case [56]. Anyhow, a greater plurality of the use of the concept should be pursued (see also 57; 42). Non-monetary valuation methods can help better reflect the complexity and depth of society's values toward nature. The expression of numerous controversies could help overcome positivists' assumptions that environmental policy can solve all problems if it has all the necessary information and knowledge. While using

the concept in its more pluralist sense and integrating non-monetary valuation methods would undoubtedly be a demanding task for policymakers (due to limited resources, knowledge, etc.), it could be worth the effort in the long run. At the academic level, this relates to the call for non-monetary valuations to become more consistent and comprehensive if they are to be better integrated into policy. Such a thing could be achieved, for example, by creating or promoting indices or dashboards that cover the values of several ES across larger spatial scales, such as the territory of the EU (e.g., surveys on ES preferences or happiness resulting from ES and connection to nature). Going hand in hand with this might be the need to deconstruct the belief that economic and social progress are equivalent and that all desirable developments must be converted into monetary equivalents to be adequately accounted for.

Second, it is essential to acknowledge that policy often lags behind science, stemming from the fact that in democracies, particularly in environmental governance, it typically takes some time for a policy to be enacted [58–60]. The policies from today are the results of the science from yesterday. This can explain why a rise in the use of the ES concept in policy could be observed starting a few years after the prominent scientific publications by Daily et al. [4] and Costanza et al. [5] in 1997. It fails, however, to explain the period of low usage between 2014 and 2020 and the sudden increase thereafter. Here, one might instead need to look at the change in leadership of the European Commission from the Juncker Commission to the Von der Leyen Commission. Additionally, in 2018/2019, environmental topics became increasingly important in societal discourse [59, 60], and actors such as the Climate Justice movement explicitly tailored their communication strategies to target policymakers and change policies [61, 62]. This at least indirectly contributed to the establishment of the Green New Deal on the European level. The time lag between the establishment of a concept in science and its broader application in policy documents may also become significant regarding NCP. This new notion may as well find its way into policy in the next few years, potentially leading to a decrease in the use of the ES concept. Yet, as NCP was explicitly coined to address the problems of commodification and oversimplification of ES (see also 63), aspects that have seemingly helped ES find consideration in policy, it remains unclear if the new notion can have a similar impact.

Third, concerning the point raised in many policies that more knowledge is required on ES, one must be careful that this kind of argumentation is not used to postpone environmental action here and now. It is essential to continue investigating and monitoring the state of ecosystems and their services. However, for a large part, a substantial body of research already exists, and what is lacking is comprehensive policies to protect and restore them [39]. For more explicit ideas on better integration of ES into policies, Bouwma et al. [24] propose to directly include the concept when drafting new or revising existing legislation. Additionally, they adopted the “Fitness Check” of the Water Framework Directive, placing greater emphasis on implementation at national and regional levels and allowing for more flexibility across governance levels.

5 Conclusion

Overall, the ES concept has gained popularity in EU policies over the past 25 years. However, increased mention of the concept is rarely accompanied by a deeper discussion, especially regarding its underlying values, explicit forms of (non-monetary) valuation,

and controversies surrounding it. The analysis revealed similar patterns in both policy documents issued by EU institutions and background reports produced by advisory bodies. This indicates a lack of transfer in the breadth of understanding from the relatively diverse scientific discourse to the relatively narrow adoption of ES in policies. One potential explanation for this is the need for policies to be as precise as possible, thereby preventing a more extensive discussion of details and contentious issues. Another explanation is that policymakers have a very particular understanding of the concept and (potentially unconsciously) overlook some parts of the discourse. This demonstrates that there is no linear transfer of the ES concept from science to policy. Instead, the concept is contested between knowledge production and application, a common phenomenon at the science-policy interface. Although this may partly be due to the nature of ES as a boundary object within this interface, the findings also indicate that environmental governance in the EU currently emphasises cost–benefit analysis, where all relevant components, even if unsuitable, must be expressed in monetary terms. Following this is the call for more plurality in the framing of ES in policy. Including non-monetary methods to value ES could, on the one hand, help demonstrate humans' dependence on nature without contributing as much to its commodification. On the other hand, presenting the concept as contentious as it is debated in academia, could humble policymakers in their pursuit of unconditional quantification and comparability of environmental conditions, leading them instead to adopt more overarching, systemic environmental policies. It could also boost the search for new, potentially more comprehensive scientific concepts, thus widening the field of vision. It remains to be seen whether ES will continue to serve as a conceptual framework for describing the benefits humans derive from nature, or whether other concepts will gain prominence, potentially coinciding with a less anthropocentric understanding of human-nature interactions in scientific, political, and societal discourse.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Data availability

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics, consent to participate, and consent to publish

Not applicable.

Clinical trial

Not applicable.

Competing interests

The authors declare no competing interests.

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