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Title: Making explicit an Ecosystem Services indicator as a policy instrument

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Abstract

Some policy-oriented concepts such as Ecosystem Services (ESS) remain widely utilized, despite obvious difficulties in operationalizing them. How does the concept persist? In a large EU Horizon 2020 project, researchers from different institutes worked together to develop an indicator of the environmental performance of agricultural practices, expressed in terms of ESS. Two observations help to theorize how ESS are progressively turned into a socially shared concept that may transform its environment and perpetuate itself. Firstly, the challenges of operationalizing ESS facilitated the formation of a group of researchers dedicated to the concept. As the project advanced, researchers progressively cut ties with the environmental sciences on which ESS are meant to be based. The interpretive flexibility of the ESS concept contributed to shaping the socially shared reality within which it was situated. Secondly, the legal obligations and procedures of the Horizon 2020 project were an essential factor for the constitutive strength of the ESS concept. As a straitjacket, the grant agreement ensured that the project maintained the researcher-indicator relationship for as long as this was not anyway stabilized. Thus, researchers were persistently oriented towards developing and expanding the ESS concept. This analysis brings new insights into how a unity is formed and maintained around relatively ill-defined concepts in large consortia that are meant to produce policy-relevant science.

Key words: Ecosystem Services indicator; Horizon 2020 project; instrumental constituency; boundary object; trials of explicitness

Introduction

Whether in European regional development programs, in periodic reviews of UNESCO Biosphere reserves, or in international research collaborations such as the one studied in this paper, it is as if environmental considerations are increasingly expressed in terms of Ecosystem Services (ESS)¹. The concept of ESS is conceived as a totalizing system aimed at encompassing all the various ways in which people relate to the environment and expressing those relations in terms of services delivered by this environment to humans (MEA, 2005; Costanza *et al.*, 2017). Yet, practitioners and researchers using ESS frequently struggle with its operationalization to inform decision making in practice (Stevenson *et al.*, 2021).

In the current paper we follow researchers who are collaborating in a large European Horizon 2020 (H2020) project to operationalize the concept of ESS into an indicator of environmental performance. The purpose of environmental indicators is to produce aggregated information to decision makers on the state of the environment. The state of the environment is generally known through the research practices of environmental sciences (Kohler, 2002). The problem for the researchers involved in producing an indicator

of ESS is that environmental scientists frequently do not study the environment in terms of ESS. The state of the environment as studied by environmental sciences thus has to be translated into a state of the environment amenable to be expressed in terms of ESS. After more than two decades of research, this translation is unfinished and the metrology of ESS therefore remains distinctly unestablished (McElwee, 2017; Rodriguez, Devictor and Maris, 2018).

The concept of ESS nevertheless continues to be widely researched and promoted, thereby stirring strong reactions and affective engagements among both practitioners (Brunet, 2022) and researchers (Schröter *et al.*, 2014; Kolinjivadi *et al.*, 2017; Masood, 2018). Several explanations have been given for the continued success of ESS and other tools for the economic valuation of the environment. Many studies and reports argue that ESS effectively contribute to reshaping human-environment interactions, fostering the integration of non-valued environmental services into policy and conservation schemes (Wunder, 2005; Maes *et al.*, 2013; Schröter *et al.*, 2014; Costanza *et al.*, 2017). Critical discursive interpretations, on the other hand, stress that the concept is widely utilized just because it fits so well with the dominant discourse and with a managerial approach to the environment (Fletcher and Büscher, 2017, 2019; Stevenson *et al.*, 2021; Maechler and Boisvert, 2023). Inquiries on the performativity of ESS have highlighted the importance of political effects rather than economic or conservation ones: the concept contributes to reconfiguring state-market-community relationships (Vatn, 2010), to disciplining the conservation movements (Dempsey and Suarez, 2016), or to neoliberalizing and commensurabilizing the environment (Robertson, 2006; McElwee, 2017).

While these analytical explanations provide useful warnings against the proliferation of ESS (Chaudhary *et al.*, 2015), they nevertheless fail to explain *how* ESS are developed and how they operate in practice. How are researchers from different disciplines aligned around the concept? By addressing this research question, we contribute to understanding the actual circumstances encountered and transformed by researchers working with ESS. This is necessary to understand how ESS continue to be developed and expanded. Our approach complements analytical narratives of neoliberalization and commensuration because an understanding of ‘how’ ESS proliferate may provide insights into ‘why’ they continue to be so widely studied and utilized (Pellizzari and Muniesa, 2023).

We therefore investigate where ESS are being studied and manipulated. We observe the work of a research consortium in Europe that is in charge of developing a framework for operationalizing ESS. This research consortium is one of the many large-scale initiatives mobilizing the concept. Its researchers conduct a review of existing literature to develop a synthetic indicator of the environmental performance of different farming systems in Europe. The work we observe can be called policy-relevant science, *i.e.* science that is directly meant to produce recommendations and tools for governance and that is therefore driven by non-epistemic as well as epistemic values (Douglas, 2009; Svetlova, 2014). It precedes the actual development and implementation of policies, which have been studied elsewhere (Jasanoff, 2004; Simons and Voß, 2018; Kolinjivadi *et al.*, 2019; Ghosh, 2023).

The main outcome of the research process in the H2020 project is, as we argue, not just the indicator itself: producing an ESS indicator consists of making something ESS can refer to as well as a public that can work with it (see Vignette 1). We find that, first, the difficulties encountered in operationalizing the ESS concept are constitutive of the reality that the indicator is intended to bring about. It not only makes the environment understandable in terms of ESS, but also produces a group of people who have invested a considerable amount of time and effort in thinking with the ESS concept. We show that the flexibility of the concept (Steger

et al., 2018) and the associated need to make things explicit (Muniesa and Linhardt, 2011) contribute to its constitutive strength. Secondly, we argue that the large-scale collaboration in which the ESS concept is mobilised, with its legal obligations and deadlines, is an essential component of this constitutive strength. Indeed, the H2020 project keeps researchers on a constant track towards the planned operationalization of the concept, despite the difficulties encountered along the way. These two findings – the need to make explicit and institutional instigation – are essential to understand how policy instruments such as ESS are developed, maintained and expanded, thus contributing to a specific instrumental mode of governing (Simons and Voß, 2018).

Vignette 1

The ESS indicator is composed of very simple categories which need to be interpretable by people – the end-users, here policy makers as well as other researchers – while not too much simplifying the environmental sciences they draw upon. Complex scientific observations in a journal of agriculture, such as for example that “*planting pasture grasses in area with Johnson grass infestation is most effective when grass is mowed combined with shallow tillage to bring the rhizomes to the surface to dry out during summer*” (Travlos et al., 2019), have to be translated into statements about the linkage between certain agricultural practices and specific ESS, such as ‘pest control’. As will be shown in the following sections, the operations that are needed for these translations are so important that neither the scientific facts the indicator refers to, nor the end-users the indicator is made for, end up being the same as initially envisioned. This is why the researchers constructing the ESS indicator also have to produce the world in which the indicator is made to fit.

In the following sections we first elaborate on how our analytical approach, grounded in material-semiotics and pragmatism, helps us to explain what exactly happens when researchers work with ESS. In the subsequent section we describe our case study and explain our stance as researchers and our empirical approach. We then delve into the struggles faced by the researchers in the consortium and the strategies they adopt during the development of the ESS indicator. This allows us to grasp the (lack of) productivity of their policy-relevant science. Our main findings are listed in the conclusion.

Analytical perspective

Indicators are meant to indicate something. They are both constructed and meant to produce signs of something which is supposed to already exist (Beunza and Stark, 2004; Marres and Rijcke, 2020). During their construction process, both the objects to which the indicator refers and the persons working with and interpreting the indicator – in our case the researchers developing the indicator – need to be somehow stabilized (Carter, 1991). In our case, the ESS indicator is designed to produce interpretable signs regarding the state of the environment in terms of ESS. However, this ‘state of the environment in terms of ESS’ does not pre-exist before the construction of the ESS indicator, as most environmental sciences on which it is based do not study the environment in these terms. Therefore, a translation is needed. This observation is not surprising to scholars who are used to material-semiotics: since all meaning is relational, sign and object are simultaneously constructed during the production of knowledge (Law, 2009).

The absence of a suitable pre-existing object nevertheless allows us to grasp a feature of ESS which might otherwise go unnoticed (see also Figure 1). Once they have decided – or have been pressed – to use the ESS concept, researchers need to make their object more explicit. These “*trials of explicitness*”, as they have been called, grasp the “*idea of being called to make an explicit statement about something that was initially*

formulated in rather loose, general terms” (Muniesa and Linhardt, 2011). For the case of indicators these moments have been shown to translate into the emergence of grey areas and the discovery of new problems (Muniesa and Linhardt, 2011). Such problems need to be addressed by the people mobilizing around the concept.

In our study, researchers and practitioners from different research institutions are collaborating in a European H2020 project with the purpose to develop an ESS indicator. The ESS concept is attractive because it acts as a boundary object (Star and Griesemer, 1989; Steger *et al.*, 2018), allowing people from different backgrounds and disciplines to work together, but also because it holds the promise of actionable knowledge (Jasanoff, 2017; Brunet *et al.*, 2018). When they are faced with a demand for explicitness, the researchers experience in practice that the sign around which they have gathered is not so clearly defined. Rather than being a problem, this lack of explicitness is constitutive because it forces the researchers to collaborate and stabilize the object. Through these trials of explicitness, ESS form strong associations between policy instruments and a group of actors that have tied their career to the further development and diffusion of the instrument (Simons and Voß, 2018).

As will become clear in our analysis, academic requirements, affects, as well as legal and professional commitments, produce a group of people dedicated to the ESS indicator, for a certain amount of time at least. A unity is formed between the researchers and the ESS indicator that they are giving shape. Such a bond develops between the researchers and their *pragmata*, objects “still in process of making” (James, 1909). This process, it has been argued, “produces in the long run a socially shared notion of the thing that the community is engaged to take as if it were true” (Eco, 1992). As our work shows, this production process is not a self-evident or automatic feat: the ESS indicator comes equipped with instructions, the research consortium generates requirements and legal obligations, and the ESS concept itself generates expectations among the researchers. While the ESS indicator cannot refer to a stable object, it is generative in the sense that it produces a stable group of researchers that unifies around it. It is this process of unification that we will analyse in the subsequent sections.

Research methods and data

A large consortium to construct an indicator for policy makers

Imagine eleven researchers in seven research groups, distributed over several institutions in Europe, collaborating to evaluate the environmental performance of ecological farm management practices. Most of these researchers identify as agricultural or environmental economists, but some are ecologists, agronomists, or geographers. They participate in a large European H2020 project – LIFT², standing for “Low-Input Farming and Territories”, coordinated by the French National Institute for Research on Agriculture, Food, and the Environment (INRAE) – which aims to “inform and support EU priorities relating to agriculture and the environment in order to promote the performance and sustainability of the combined rural system” (LIFT consortium, 2018). The indicator of environmental performance is just one of the deliverables of LIFT and should become one of the components of a multi-scale sustainability assessment of European farming systems. The overall project is composed of different work packages that are all geared towards a final objective: the delivery of “new composite indicators that integrate all performance dimensions [of agro-ecological practices] jointly (technical, economic, private social, environmental, employment)” (LIFT consortium, 2018). It responds to predefined requirements stipulated in the H2020 objective, namely “increasing production efficiency and coping with climate change, while ensuring sustainability and

resilience” (LIFT consortium, 2018). Performance indicators are considered to be useful for this because “they summarize complex, multi-dimensional concepts in a way that is easy to interpret” (LIFT consortium, 2018).

We observe the construction process of one of the indicators developed in the project: the indicator of environmental performance of agro-ecological practices. During a Rapid Evidence Assessment (REA) of other reviews – *i.e.* a review of reviews, limited in time and scope – data from environmental consequences are first extracted from existing literature on agricultural practices in Europe. Reviews in environmental sciences are scanned for evidence concerning the consequences of these practices for different ESS, such as “soil nutrient cycling”, “freshwater purification” or “improving the attractiveness of the landscape”. In a second stage these data are reassembled into a list of sub-indicators representing the different ESS that can be provided by the agricultural practices.

The environment thus appears to the researchers in the material-semiotic form of scientific reviews, *i.e.* combinations of *inscriptions* (Latour, 1987), in the field of agronomy, soil science and ecology (taken together as environmental sciences). These inscriptions need to be translated into ESS. The indicator thus has to build a linkage between the state of the environment as it is currently known in literature and a clear and understandable signal in terms of ESS. The linkage is made possible by two sets of *instructions* (Asdal and Cointe, 2022): first, the methodological instructions for the REA and the classificatory rules of the ESS; second, the guidelines and constraints of the grant agreement. By following the effects of these two sets of instructions, we observe the trans-formative work of the research collaboration in two related aspects. Firstly, we investigate the *transformation* of inscriptions from environmental sciences into new inscriptions in terms of ESS. Secondly, we attend to the *formative* potential this collaboration has for the group of researchers themselves.

In the process of constructing an indicator, a group of researchers is thus tied to this indicator. Our research stance is to study this dynamic, as illustrated in Figure 1. This stance is loosely inspired by Peircian semiotics, in which a sign stands for an object in a way that shapes the relation between the interpretant and that object. The solid triangle in Figure 1 represents the H2020 project. In their attempt to study the linkage between the state of the environment (the object) and the ESS delivered by this environment (the sign), the researchers of the H2020 project construct the indicator of environmental performance (the dynamic object).

Ultimately, this indicator should be interpretable to a specific group (the interpretant). Those for whom the indicator will be relevant are supposed to be the ones interested in knowing the state of the environment, but as we will demonstrate, it is primary researchers of the H2020 project themselves who are engaged. In this paper, we investigate the relation between the indicator of environmental performance under construction and the researchers of the H2020 project. Our work (depicted by the dashed triangle) thus observes the development of the indicator and provides an interpretation of the researcher-indicator linkage being constructed throughout the project.

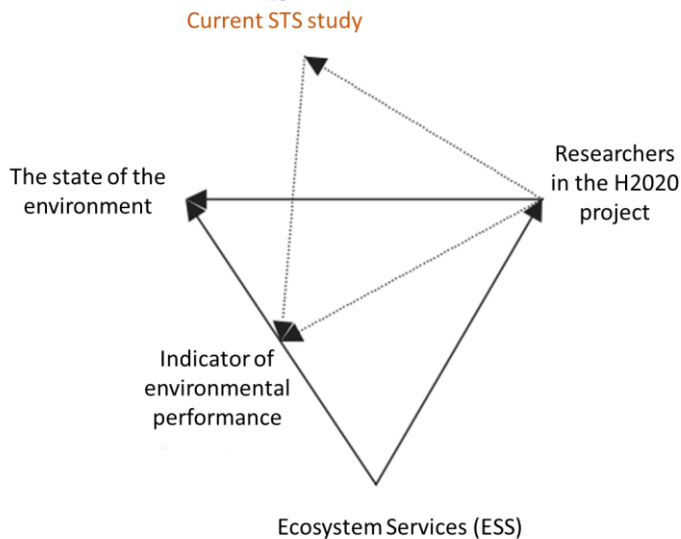


Figure 1: How our STS study related to the research setting (adapted from Kockelman (2005)). In their attempt to study the linkage between the state of the environment (the object) and the ESS delivered by this environment (the sign), the researchers of the H2020 project (the interpretant) construct the indicator of environmental performance (the dynamic object).

Researchers' positionality and data

The first author of current paper initiated and conducted the STS study, while the second and third authors are the main researchers involved in the construction of the environmental indicator. All the meetings of the latter two have been systematically recorded from mid-2020 onwards for the purpose of current STS *study. Since this has likely influenced the work of the researchers involved in the process, we shortly elaborate on our positionality below.

Recently converted to sociology of science and after having finalized a PhD in environmental economics, the motivation of the first author to conduct this STS study derives from his in-between position: knowing both the practices in environmental economics (Schröter *et al.*, 2014) and the stringent critiques one can find in geography and sociology (Gómez-Baggethun and Ruiz-Pérez, 2011; Fletcher and Büscher, 2017), the initial objective of the first author has been to render reflections on environmental economics more targeted and more effective. The third author is the head of the research group that coordinated the development of the indicator. Professor in environmental economics, with a Master in both agricultural engineering and economics and a PhD in economics, she participated in writing the grant proposal for the H2020 project. The second author is a PhD student under her supervision. She was hired on the H2020 project and has conducted the majority of research activities for the development of the indicator. She has a bachelor's in biology and a Master in sustainability and climate change.

The current study has been made possible by nurturing a trust relation between the authors. It was agreed that the first author would conduct the STS analysis, based on project documents, emails and transcribed recordings of meetings and interview, and subsequently write the scientific article. The second and third author have been involved in the final revision of the STS article and as co-authors in order to ensure precision

in the reporting as well as trust and accountability all along. We have cultivated the proximity and distance that is required to open up the “gaps in meaning” that are necessary for this kind of situated research (Rose, 1997). This likely has had some influence on the H2020 project itself. As stated by one of the researchers in a comment on a preliminary draft of current paper: “I was very aware of someone studying the work we were doing, and sometimes spent a lot of time, maybe more than I would have otherwise, thinking things through to ensure that I could justify my actions to you later on” (Researcher 1).

Besides interviews with the second and third author of current paper, five other researchers from different research institutions involved in the H2020 project have been interviewed with a focus on what they did during the research and why. A substantial number of other documents has been collected: more than 30 official documents related to the H2020 project, including the grant agreement and relevant milestones and deliverables; internal communications and documents with instructions for the REA; Excel tables with data extracted during the REA; as well as transcriptions of 13 recorded meetings of 1 hour or more; tens of notes of shorter meetings; transcriptions of 3 workshops with stakeholders; and, finally, feedback on drafts of reports and on scientific manuscripts related to the indicator. An initial draft of the current paper has been shared with the 11 researchers involved in the indicator development. A meeting was organized, recorded and transcribed in order to validate and nuance the findings. Quotes from discussions and interviews are labelled as Researcher 1, Researcher 2,... in order of appearance in the text, while documents are referred to as Doc1, Doc2,... (Table 1).

Table 1: Overview of the documents cited in the text, in order of appearance.

Doc 1	Grant agreement of the H2020 research project. This grant agreement can be found online (LIFT consortium, 2018). The development of an environmental indicator is part of Work Package 3.
Doc 2	Deliverable D1.1: Review of the definition of the existing ecological approaches, part of Work Package 1.
Doc 3	Excel table used to extract data from reviews into categories of ESS, illustrated in Figure 2.
Doc 4	Rejection letter by editor of <i>QOpen</i> journal on the 5 th of June 2023
Doc 5	Final rejection letter by editor of <i>Ecological Indicators</i> on the 28 th of September 2021
Doc 6	LIFT Deliverable D7.6: How to improve the adoption, performance and sustainability of ecological farming. This final scientific deliverable summarises the methodologies used and the key results for the main research activities that were carried out (published on 29/04/2022) ³ .

A concept equipped with instructions

The methodology for the development of the indicator is, in principle, quite straightforward. During the Rapid Evidence Assessment (REA) both quantitative and qualitative information on environmental consequences is collected in a large Excel table, together with an evaluation of the scientific papers’ quality. This quality assessment is later used to introduce a weighting that accounts for a (supposedly) unequal reliability of available evidence. The table combines at least three classificatory systems, *i.e.* instructions, into two different sections (Figure 2). The first section is about the semiotic content of the reviews, *i.e.* what the reviews say about agricultural practices and their environmental consequences. The second section treats the reviews more as containers of information and evaluates the quality of these information carriers. Together these sections produce a score of the strength of available evidence on the linkage between a certain agricultural practice and a specific Ecosystem Service.

The first section draws on two classification systems: a typology of farming systems, constructed in a preceding work package of the H2020 project (Doc 2, deliverable D1.1), and an internationally recognized

classification of ESS. The former typology classifies farming systems according to their degree of uptake of agroecological practices, ranging from “agroecology” as the most ecological farming system cluster until “conventional, or standard farming, systems” as the least ecological system. The Common International Classification of ESS (CICES 2018) from the European Environmental Agency is subsequently used as a guiding document to classify different environmental consequences into the appropriate ESS. Space is foreseen in the table for both qualitative and quantitative evidence, as well as for comments and excerpts of the reviews in case the reviewers would feel the need to add context and nuance.

The second section of the table consists of a list of 27 questions, in the form of checkboxes, to evaluate each of the reviews included in the REA. REA are conditioned by a set of criteria which define how to do a literature review. The gold standard is set by Cochrane reviews in medical sciences, an extremely protocolized, nearly mechanized, process to identify scientific evidence in literature (Cochrane, 2022). While reviews in environmental sciences are generally less protocolized, the researchers draw on Cochrane standards as a guideline for their REA and as a way to evaluate the quality of the reviews under study. It is based on the premise that not all review papers are of the same quality and that an assessment of confidence is needed when conducting a REA. ‘Quality assessment is part of the procedure, the same way the abstract screening and full text screening and data extraction are’ (Researcher 2). The quality criteria comprise checkboxes such as “all databases used in the search are listed”, “the study includes the final reference list of excluded individual studies”, “information on the effect sizes of each individual study is provided” and “sources of funding for the review are described” (Doc 3, Excel table). Together these questions, on the information carrier rather than its content, have been used to attribute a score to each of the linkages in the Excel table, based on the thus derived quality of its information source.

The table is used to extract information from the reviews, reclassify this information in the form of linkages between a given set of agricultural practices and ESS, and subsequently evaluate the strength of these linkages by looking at the number of observations, i.e. instances of a practice-ESS linkage found in each review, and the quality of the papers they are derived from (Figure 2). A single score is constructed by counting the number of observations weighted for their quality. The score supposedly indicates the strength of a linkage: it is a measure for the amount of certainty in scientific literature on the correlation between an agricultural practice and the provision of an ESS. This score is considered to be useful for the governance of both research and agriculture: either there is scientific evidence of the benefits of a certain practice, and one can tell policymakers to subsidize it, or there is no scientific evidence and policy should stimulate further research. In both cases the indicator is thus intended to support evidence-based policymaking, wherein technocrats orient subsidies based on the information provided by the indicator, and wherein farmers or researchers are expected to respond behaviourally to such incentives. True, admits Researcher 3 during an internal discussion on this subject, ‘it would be short-sighted to say that there is no link if we do not find a link, but on the other hand, [if we do not find evidence] there is in fact no link on which to base policy’. Note that this illustrates the famous observation of Latour: that “nature” as we know it is only as strong as the scientific networks that are composing it (Latour, 1993).

The whole project is thus founded on two assumptions: (1) that a practice-ESS linkage can be found or made, and (2) that the indicator resulting from this linkage is easily associated with users that pre-exist the indicator. In the following sections, we will observe that (a) constructing this linkage is more challenging than initially anticipated (section 5), (b) projected users are not as easily enrolled as imagined (section 6) and (c) the challenges encountered along the way result in the constitution of a group that was not necessarily

envisaged at the outset, yet whose existence will nonetheless justify the indicator in the end (see Conclusion).

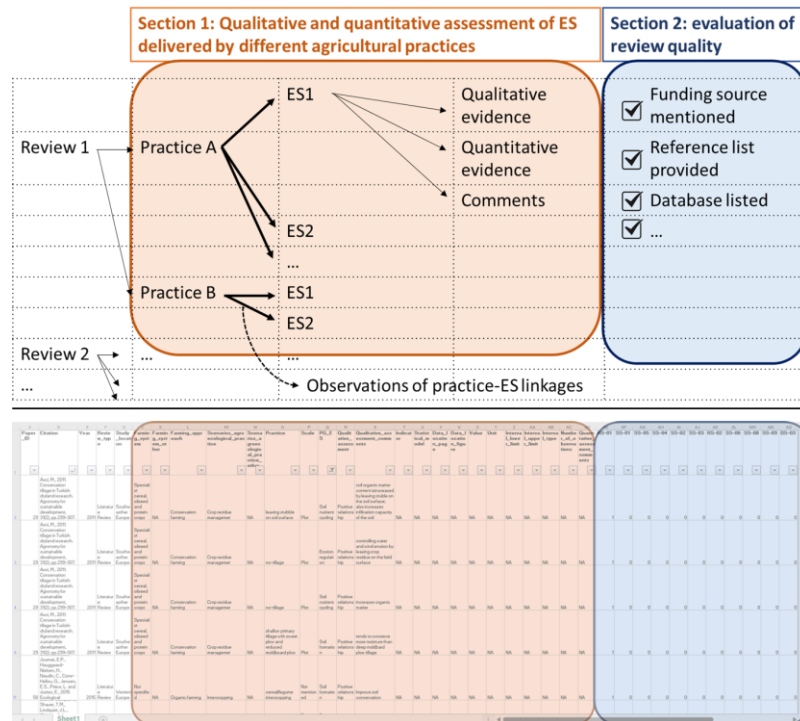


Figure 2: The table combines three classificatory systems to extract information from reviews, reclassify it in the form of practice-ESS linkages and produces a score for each of these linkages. The three classification systems are (1) the list of agricultural practices, (2) the ESS list and (3) the list of criteria to evaluate review quality. The upper part of the Figure is a schematic representation, while the lower part is a screenshot of a section of the table in Excel.

Instructions fall short in practice

While the instructions that accompany the ESS concept are numerous and detailed, they cannot (and do not aim to) prevent practical difficulties and ad hoc decisions during the operationalization of the concept. The challenges of database construction in environmental sciences have been beautifully described and analysed elsewhere (Bowker and Star, 1999; Bowker, 2000; Robertson, 2006; Leonelli, 2016). We therefore just provide a few examples to illustrate the struggles faced by the researchers in our case. These struggles serve as trials, compelling researchers to explicitly address their adherence to the ESS framework rather than to the environmental sciences upon which ESS is meant to be founded. Indeed, operationalizing the ESS concept necessitates severing some ties.

It is not always clear which detailed context and nuance found in the reviews can be dropped and which have to be conserved during data extraction. Regional and climatic information, technical details, warnings and conditionalities are sometimes dropped or noted down in a comments section of the Excel table. When these warnings and conditionalities surrounding a result are deemed too strong, the consequences are labelled as “inconclusive” (Doc 3). Consequences, when identified, subsequently have to be classified into the appropriate ESS. When several chemical components are reported separately, such as levels of soil organic carbon, total nitrogen content, nitrogen use efficiency and microbial biomass, they can be classified as different observations of the same ESS (e.g. “soil nutrient cycling”) or as proxies of different ESS, such as

“freshwater purification” or “carbon sequestration”. To identify consequences one moreover needs a clear action and a baseline. While the baseline should be the conventional counter-practice, in the reviews it is not always clear in practice what this actually means.

In some respects, during the operationalization of the ESS concept into an indicator of environmental performance, the instructions accompanying the concept appear too coarse. They are inadequate in preventing ad-hoc decision and subjective judgements. The promise of establishing a clear connection between the environment as it is known (in environmental sciences) and indications in terms of ESS appears challenging to realise. This leads to long discussions and sometimes frustration. As Researcher 2 puts it, ‘it’s all based on language and interpretation’. To smoothen the process, extensive space is foreseen in the Excel table to add comments and nuance. This proves useful in many cases: ‘Sometimes [when it got too hard] I ended up, like, copying the whole paragraph, putting it in the Excel file, just so if anyone [in the research collaboration] wanted to double check how I’d read it, they had the original thing without having to go into the paper’ (Researcher 2).

Another difficulty relates to the units of the observations. The quantitative data in the reviews are expressed in all sorts of units, whereas qualitative observations are expressed relative to a baseline as either higher or lower. This heterogenous set of quantitative and qualitative descriptions of consequences has to be transformed into a coherent table expressed in one and the same simple unit: improvement (+1), degradation (-1) or no conclusive effect (0). This entails three important consequences: firstly, for each of the identified effects a value choice has to be made. This is straightforward in some cases: when a practice is associated with a higher soil stabilization, this counts as a positive effect on “erosion regulation”. In some cases it is more complicated: should a positive correlation between a practice and the number of small mammals, including rodents, be treated as a negative consequence for “pest and disease control”? Secondly, while reducing the observations to simple numbers, data are stripped of all the remaining information, doubts and resistances which reviewers noted down in the comment section of the Excel table. Hesitations and frustrations in the previous stage thus disappear here behind the numbers. Third, the choice for three simple categories also leads to the loss of quantitative information, such as biophysical data. This is experienced as a sacrifice, a concession to the requirements of some ESS, such as the cultural ones, which cannot (yet) be expressed in quantitative units.

Note that it is not the environment, with plants, animals and ecologies, which is gotten rid of here, but concepts from environmental sciences, ecology and agronomy. While the concept of ESS was originally coined in environmental sciences (Costanza *et al.*, 2017), these sciences frequently give rise to concerns and considerations which are not captured by the ESS framework. While ESS thus derive their legitimacy from environmental sciences, they demand severing certain ties with these sciences for their operationalization (see Mertens (forthcoming) for a detailed analysis). Scale, threshold and hysteresis effects, for example: several meetings during the first two years of the project were entirely focused on incorporating these effects into the indicator. How to account, one could ask, for the fact that species need a certain amount of a certain habitat to survive in the long run? These concerns were already present in the grant agreement, e.g. “[...] certain minimum size is needed before environmental benefits are realized” (Doc 1). At the end of the project little remains of those concerns. Likewise, concerns regarding multispecies dynamics (e.g. when there is a synergy between cover crops providing nectar in early spring to a specific type of solitary bee which also happens to be an important food to a bird species nesting in nearby small landscape elements) and seasonality do not fit the ESS framework and have thus faded away in the course of the project.

This progressive removal of concepts from environmental sciences alienates some researchers from these sciences. Researcher 5 in the research team therefore stresses the importance of ‘being very transparent about the assumptions we make and also about the potential weaknesses that are involved with the approach’. This is not sufficient to convince all scientists, though, since the paper describing the methodology to construct an ESS indicator has been rejected several times before being finally published (Van Ruymbeke *et al.*, 2023). Reviewers repeatedly questioned the scientific relevance of the indicator: “the methodology may well be novel but does it provide useful evidence or information?” (Doc 4), and “[the indicator does] not provide any insight on how (why) and how much (quantity/intensity) a distinct management practice influences the provision of ESS” (Doc 5).

Sound policy advice and changing concerns

The severing of ties does not happen over one night, but through an iterative and sometimes complicated process. Several research teams in different universities in Europe sat together repeatedly to discuss on how to extract relevant information from papers in environmental sciences, how to interpret this or that consequence of an agricultural practice and how to make it fit in one of the categories of ESS. In the words of Researcher 4, their team has moved ‘from idealism to pragmatism’. This has been made possible by the clear guidelines, predefined milestones, deadlines and joint deliverables of the research project.

Often perceived as a burden, the multiple bureaucratic procedures required by the grant agreement actually facilitate this process. As stressed by Researcher 1, the grant agreement ‘is the big document, whenever I have a question about [the project], I go there’. The instructions from the grant agreement are sometimes perceived as a straitjacket, but that does not imply that everything is fixed. Researcher 6 therefore stresses: ‘I did not have at all in mind what it was going to be’. Indeed, ‘the more in-depth thinking is something that we worked on in course of the project’ (Researcher 3). The grant agreement nevertheless assures that everyone is working in the same direction. Researchers regularly have to ‘tick the boxes’ (Researcher 3) of this legal document. With some vehemence Researcher 3 argues: ‘we constantly have to balance. [We cannot] spend too much time on those very interesting things that emerge, because we have that other list we need to follow.’ The indicator of environmental performance, therefore, must be produced with limited consideration for new insights, evolutions and changes throughout the project.

According to some researchers in the project, ESS are ‘a reframing more than anything else’ (Researcher 2). They are used ‘to provide sound policy advice’ in order to provide ‘a scientific background on what [agricultural practices] to support or not’ (Researcher 3). The use of ESS is not self-evident to all researchers involved in the process. As stated by researcher 2 in a written comment on a preliminary draft of a paper, ‘as an ecological economist, I am wary of throughput representations of systems. [...] Not to say that I object to it as a framework to use here, or that it’s not useful. It’s just that it’s a very (neoclassical) economist way of representing it’. The ESS concept is valued for its applicability and policy relevance. It is also considered useful to make accessible all the knowledge that is already there. As put by the same Researcher 2: ‘we probably have all of the environmental evidence or most of what we need, but we just haven’t bothered synthesizing it in’. In the end, ESS have the potential to ‘make people aware of how valuable nature is’ (Researcher 1). ESS are ‘a way to send the message, or to communicate with a certain group of people that otherwise might not receive the message in a different way’ (Researcher 1). Thus, ESS is a valuable concept because it is considered to be practically useful.

The assessment of the practical utility of the ESS indicator is not universally endorsed within the H2020 project. To our knowledge this has not resulted in overt disagreements during meetings. However, the final scientific Deliverable (Doc 6) of the project, produced in work package 7 under the leadership of a different team, explains why the ESS indicator is not utilized in subsequent analyses and has only been included “to provide additional insights on environmental performance [of agro-ecological practices]”: “the limited availability of landscape-scale data, the use of scenarios, and the need to rapidly apply a straightforward methodology across diverse case study areas, favoured a qualitative assessment of each adoption scenario in terms of their impacts against a set of regionally-specific sustainability objectives.” Stakeholders indeed “expressed scepticism about the ability of assessors to accurately measure improvement in ecosystem service provision due to farm management” (Doc 6).

The grant agreement and the promise of policy-oriented results thus ensure that the researcher-indicator connection stays in place as long as the constituency has not been stabilized (see Figure 1). While this does not prevent resistance, it pushes researchers to stick to the initial objectives and advance in developing the ESS indicator in spite of the challenges faced along the way.

Thinking with an ESS indicator

The H2020 project was finalized in 2022 and ended in 2023. It produced a large number of deliverables in the course of its lifetime and obtained all the necessary validations from the European Commission. A first paper on the ESS indicator has been published in *Sustainability* (Van Ruymbeke *et al.*, 2023) and a PhD on indicating the environmental performance of agricultural practices has been defended in January 2024. The indicator remains a very theoretical feat, which is not (yet) applicable for policy. It is “a first attempt at summarizing the multitude of evidence that is available in the literature in a concise, intuitive, and transparent manner” (Van Ruymbeke *et al.*, 2023). The Excel table has not been converted into a usable tool, nor has the REA been expanded to thoroughly cover all literature in environmental sciences. What has then been realized?

Researcher 2 claims to be less concerned with ‘detailed’ concepts from environmental sciences and to have learned ‘to make a choice between many details [about context and biophysical aspects] and pragmatic decisions’ (Researcher 2). The ESS indicator appears to be a tool for thinking and mental processing, rather than a tool for communicating about the state of the environment. What the ESS indicator currently indicates is the distant possibility to measure the environmental performance of European agriculture in terms of ESS. As researcher 3 signals at the end of the process: ‘the good thing is that [...] someone could run [the analysis] with proper data from a proper database’. According to Researcher 2 it is therefore important to stress that the ESS indicator is ‘a framework’ and that one should not be ‘cherry picking’ in the final results.

The ESS indicator is thus ready to be further developed. What has been produced through the H2020 project is a draft of an ESS indicator – equipped with instructions, but no ‘proper database’ (Researcher 3) supporting it, nor practical applications – as well as a group of researchers that is associated to it. This is perhaps a good foundation for future research projects. At this stage, however, the main outcome of the research project is the fact that several groups of researchers tried to operationalize the ESS concept, committed time to it and tied part of their career to the indicator development. At least for the duration of the research project the ESS indicator of environmental performance has been a real object for these researchers. For now, these researchers are the main users (in the semiotic terminology of Figure 1, they are the interpretant) of the ESS indicator. They are likely to further mobilize the concept of ESS in their future careers (inside and outside

academia) and thus have become part of the instrument constituency (Simons and Voß, 2018) which ensures that ESS are perpetuated and expanded over time.

Discussion

In this paper, we have provided evidence of how researchers from different disciplines are aligned around the concept of ESS and how this contributes to its development and expansion. Our analysis highlights two factors that are important to understand how researchers become committed to the ESS concept.

Firstly, people have devoted time and effort to developing the ESS. The indicator is an unfinished result of the researchers' work and a potential source of additional work on ESS in the future. In the long run, these repeated efforts to make ESS practically useful and explicit may contribute to producing a socially shared notion which is workable in practice and therefore validated as effective and fruitful knowledge (Svetlova, 2014). Yet, the environment to which the ESS indicator refers is not the environment known by environmental sciences. Our results show that producing an indicator of environmental performance involves severing ties with the environment as studied by environmental sciences, rather than reinforcing these ties.

New ties are thereby constructed between the indicator and the community of researchers working with it (see Figure 1). While this observation is in line with previous research (Robertson, 2006; Devictor and Bensaude-Vincent, 2016), we additionally show the great effort this requires. Environmental sciences are not weak: their knowledge-production methods are well-established (Kohler, 2002) and they have proven their capacity to generate new concerns and associated institutions, such as the degradation of biodiversity (Takacs, 1996; Borie *et al.*, 2021). Mobilizing environmental knowledge and translating it into ESS therefore necessitates much effort with a disciplining framework.

Secondly, we show that the trials of explicitness successfully contribute to constituting a community attached to developing ESS because participants are engaged in large-scale collaborations with many partners, procedures and legal obligations to deliver reports and publications within relatively strict deadlines. The structures and instructions that accompany ESS were disciplining the researchers involved in the H2020 collaboration, pushing them to overcome the practical challenges, professional hesitations and ideological resistances they have been facing along the way. These guidelines are an important reason for why the ESS indicator may finally become constitutive of an effective reality and an instrumental mode of governance (Simons and Voß, 2018).

Although our findings are non-deterministic, they suggest evidence for the dynamics at work around concepts with interpretive flexibility mobilized in large projects. Research programs and projects, even when aiming for policy-relevant science, do however not necessarily have to serve an instrumental mode of governance founded on detached indicators and incentive-based policy. The researchers involved in the project could also have chosen to engage more with the questions and resistances that came up throughout the process. If they had been exposed to different conceptual frameworks, they could have chosen to develop alternative approaches. The outcomes of the research project studied here are partly driven by the strong conviction of the Work Package leader (who equally supervised the PhD student) that such instruments are needed to guide policy making on both research and farming.

Our paper further shows the value of collaborative approaches to study policy-relevant science with a perspective from Science and Technology Studies (STS). Despite ideological differences between the first

author of this paper and the researchers in the H2020 project concerning the need for indicator-based environmental governance, the current study has generated interesting discussions. For example, at the PhD defence in early 2024, there was a discussion about why neither the environment nor the diverse concerns of farmers were adequately captured by the indicator developed in the project. While the core foundations of the ESS indicator were not fundamentally questioned, these reflexive discussions nevertheless contributed to denaturalizing indicators, thereby preventing them from becoming self-evident. Without the reflexive distance cultivated in this paper, the many struggles and trials faced during the indicator development are insufficient to reach such denaturalization. Indeed, as argued by Latour, while researchers are very aware of the practical difficulties and *ad hoc* decisions while they are conducting their research, they tend to quickly forget the extent of their efforts and naturalize the outcomes of their work once these outcomes have been stabilized (Latour, 1987, 2017).

Conclusions

There is surprisingly little research on how governance instruments are made and come into being (Voß, 2016). Our analysis illustrates how the concept of ESS is developed and expanded, despite widespread resistance and little policy relevance in practice. Drawing on an approach that is loosely inspired by Peircian semiotics, we highlight two factors that are important in the process of making and maintaining an environmental indicator. Firstly, the challenges faced during the operationalization of concepts that have an interpretative flexibility contribute to forming a community of practice, *i.e.* a group that has had difficulties implementing the concept. Secondly, we show that the consortium's procedures and legal obligations play a disciplinary role for the concept.

Contrary to data-driven research (Leonelli, 2016), or classical inductive or deductive approaches, the research we observe here is meant to be policy-oriented. The Horizon 2020 (H2020) project aimed to develop an experimental framework that can contribute to rationalizing decision making in environmental and agricultural policy at the EU level. It thus aimed at developing instruments to monitor the environment and orient policies accordingly. The concept of Ecosystem Services (ESS) functioned as a guiding star towards the realization of this objective. During the H2020 project, a unity was created around the ESS indicator. We show how the researchers purify elements from reviews in environmental science and ecology from their disciplinary ballast and reassemble the elements into something new. In this process the abstract concept of ESS is conferred a substantial object and a research group to which this object matters.

The many guidelines and milestones of the H2020 project, lists of agricultural practices and standards for a proper rapid evidence assessment act as written instructions that support the development of the indicator. In practice, however, these instructions fall short; researchers face the strenuous task of stabilizing the meaning of ESS. This forces them to actively contribute to the reality that is evoked by the ESS concept. In their work to develop the ESS indicator, they get acquainted with the concept, learn to think with it and effectively form an (albeit temporary) community of practice around it. The development of concepts and indicators underwent trials of explicitness (Muniesa and Linhardt, 2011), which contributed to the socially shared reality and neoliberal governance mode that they are intended to foster. We show that the environment denoted by the ESS differs from the environment as understood through environmental sciences. Likewise end users are somewhat misaligned with the researchers and policy makers originally meant to benefit from the research.

Many studies have investigated the difficulties associated with implementing quantitative policy instruments, but few have looked at their prior development phase (Simons and Voß, 2018; Ghosh, 2023). Describing the development of an ESS indicator in a European research collaboration, our analysis partly explains how the concept persists. Our findings therefore provide empirical grounding to critical analyses that may wonder how certain concepts proliferate despite serious difficulties in operationalizing them. Other indicators and concepts with interpretive flexibility as well as institutional support may display features similar to the ones observed here. The analysis therefore can help grasp the workings of other concepts with interpretive flexibility in academic and non-academic research collaborations.

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recreation and spiritual values, CICES 2018). While there has been a recent push to talk of “nature benefits to the people” instead of ESS (Pascual *et al.*, 2017), the latter concept is still widely promoted at the international and local level. For an example of a European Interreg program framed in terms of ESS, see <http://project-ecoserv.eu/>.

² More information on the project here: <https://www.lift-h2020.eu>

³ All deliverables can be accessed here: <https://www.lift-h2020.eu/deliverables/>