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Data Paper

Evaluation of the ecosystem services approach in agricultural literature

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Abstract

Background

The ecosystem services approach is increasingly used in scientific literature all over the world. Originally the concept was proposed for natural or semi-natural ecosystems. However, for some years the approach is also used in literature related to agriculture. While ecosystems under agricultural management provide important services, the management also has negative environmental effects and consumes certain ecosystem services. This raises the question in what relation and to which extent the ecosystem services approach is applied in agricultural research. Moreover, it is interesting where and on what scale studies were conducted.

New information

The purpose of this literature data article is to give an open accessible database to analyse ecosystem services indexed literature with an agricultural context. It gives an overview on i) the assimilation of the ecosystem services concept across several scientific disciplines that deal with agriculture, ii) the scale and regions of studies. Further, we evaluated iii) how the relation of agriculture to ecosystem services is conceptualised.

This database enables potential users to get better insights into the application of the ecosystem services approach on agricultural research questions and whether new or different findings can be generated in comparison to conventional disciplinary research.

Keywords

Adapted Delphi, Experts, Scopus Advanced Search, Search algorithm, concept implementation

Overview and background

The number of articles indexed as *Ecosystem Services* (ES) is rapidly increasing, especially since 2005 – the year the Millennium Ecosystem Assessment was published (MEA 2005). The same holds true for the subset of ES approaches that specifically address agricultural issues, but with a smoother curve regarding publication quantity (Huang et al. 2015). Originally, the concept was conceived for natural or semi-natural ecosystems, from which ES *flow* (Burkhard et al. 2014) or *cascade* (Haines-Young and Potschin 2010) to humans. However, ecosystems worldwide are increasingly transformed by humans. Especially when considering agricultural ecosystems – one of the most affected types of ecosystems – it becomes clear that human benefits are in fact induced by the flow that comes out of natural capital, work (human capital), and inputs of matter and energy. This characteristic is covered by an updated definition of ES as "the contributions of ecosystem structure and function – in combination with other inputs – to human well-being" (Burkhard et al. 2012). It is currently being discussed to introduce the term agrosystem service to specifically reflect the anthropogenic share through ES from agriculture (Wiggering et al. 2016).

Agricultural ecosystems are key providers for several ES (Harrison et al. 2010): i) the provision of food, feed, fibre, biogenic-chemical matter, fuel, ii) the regulation of pollen transfer and agricultural pests, and iii) recreation, education, cultural heritage, and sense of place. On the other hand, agriculture is a form of land management with several important implications for the achievement of the United Nations Sustainable Development Goals, for example zero hunger, climate action, or life on land – to mention the most obvious interconnections only. The MEA (2005) particularly highlighted the global ES damage attributed to agricultural expansion. Subsequently, agriculture was perceived as both a

provider and a consumer of ES (Swinton et al. 2007, Power 2010). Therefore, very different relations between ES and agriculture have to be considered.

The purpose of this literature data article is to give an open accessible database to analyse ES indexed literature with an agricultural context. This literature analysis follows the ES classification from *The Common International Classification of Ecosystem Services (CICES)* (Haines-Young and Potschin 2016). Large scale literature analysis can improve the debate about strengths and weaknesses of the concept (e.g. Norgaard 2010, Gómez-Baggethun et al. 2010, Plieninger et al. 2014) and about the capacity for the ES concept to shape environmental research. Reflecting review results (e.g. Vihervaara et al. 2010, Tancoigne et al. 2014), our research addresses the degree of assimilation of the ES concept across several scientific disciplines (or topics) that deal with agriculture. One major output is a quantitative overview about the *de facto* use of the ES concept in current agricultural research studies based on qualitative assessments of 821 papers. Therefore, the evaluation of the journal articles and reviews distinguished publications that fully implemented the concept (and give quantitative or qualitative assessments of certain ES) from those that only slightly or did not implement it, and thus, were labelled with ES but did not truly integrate the concept as it is meant to be used (for details see the *Methods* section).

Additionally, the spatial allocation based on world regions and the scale of the conducted research was indicated, when possible (especially for case-studies). This should give opportunity for further interpretation of the results.

Methods

For creating a meta-analysis database (Suppl. material 1), we first conducted a systematic literature search. The resulting articles were submitted to an analytical coding scheme and an expert rating regarding the implementation degree of the ES concept, which was supported by an adapted Delphi process.

Sampling strategy and search query

We conducted an *Advanced search* in Scopus®. We used the search term **ecosystem service** in combination with **agr** or **farm**. This resulted in a total number of 821 articles from the year 2005 onwards, last updated on 31st of December 2015. The document type was restricted to articles and reviews. The search terms had to be given in the title or in the author keywords to find those articles whose authors explicitly wanted to refer to ES.

The search can be reproduced with the following search queries. A search conducted later than the date at which we conducted it, will result in more articles as some articles are added to Scopus® after that date, also for earlier years. The search query can be used by applying the [*Search Query "All Articles*"] and other specifications (see below) for the other keywords.

All Articles

(

(AUTHKEY ("*ecosystem service*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*ecosystem service*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND ((AUTHKEY ("*agr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*agr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re)))) OR ((AUTHKEY ("*farm*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*farm*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))))

)

Governance, policy, institutions

([*Search Query "All Articles*"]

AND ((AUTHKEY ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))))

)

C and N compounds AND NOT governance, policy, institutions

([*Search Query "All Articles*"]

AND ((AUTHKEY ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR

DOCTYPE (re))) OR (TITLE ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))))

)

Soil AND NOT C and N compounds, governance, policy, institutions

([*Search Query "All Articles*"]

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)

Climate AND NOT soil, C and N compounds, governance, policy, institutions

([*Search Query "All Articles*"]

AND ((AUTHKEY ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar)

OR DOCTYPE (re))) AND NOT (AUTHKEY ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))))

)

Biodiversity, conservation, pollination, pest AND NOT climate, soil, C and N compounds, governance, policy, institutions

([*Search Query "All Articles*"]

AND ((AUTHKEY ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("*poll*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poll*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("*conserv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*conserv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND

(DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))))

)

Water AND NOT biodiversity, conservation, pollination, pest, climate, soil, C and N compounds, governance, policy, institutions

([*Search Query "All Articles*"]

AND ((AUTHKEY ("*water*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*water*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poll*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poll*") AND

PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*conserv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*conserv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))))

)

Assessment, cultural AND NOT water, biodiversity, conservation, pollination, pest, climate, soil, C and N compounds, governance, policy, institutions

([*Search Query "All Articles*"]

AND ((AUTHKEY ("*assess*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*assess*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (AUTHKEY ("cultur*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("cultur*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poll*") AND PUBYEAR > 2004 AND

PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poll*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*conserv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*conserv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*water*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*water*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))))

)

Negative mask (Other)

([*Search Query "All Articles*"]

AND NOT (AUTHKEY ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poli*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*institut*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*govern*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*carbon*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*nitr*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*ammo*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*soil*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*climat*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*biodiv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*poll*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*poll*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*conserv*") AND

PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*conserv*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*pest*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*water*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*water*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("*assess*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("*assess*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) AND NOT (AUTHKEY ("cultur*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re))) OR (TITLE ("cultur*") AND PUBYEAR > 2004 AND PUBYEAR < 2016 AND (DOCTYPE (ar) OR DOCTYPE (re)))

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Analytical framework

We created a search term hierarchy (see Fig. 1) to avoid a single article being assigned to several scientific fields. The group of articles indicated by keywords from the highest level were assigned with no restrictions, while the article groups with lower level keywords gradually excluded the keywords from the higher levels. For example, the group of articles dealing with the topic of C and N compounds would include papers with the keywords **carbon*, *nitr*, *ammo**, but not any of those including the keywords for papers on governance, i.e. **govern*, *poli*, *institut**.

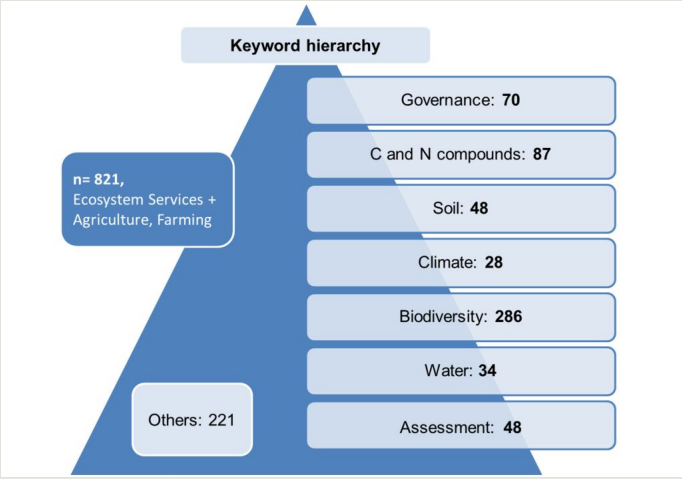

Figure 1.

Hierarchy of search terms and their resulting amount after the *Advanced search* in Scopus®.

After the distribution of the articles to each group, the experts were able to exchange papers between groups according to their expertise in the very specific field and the content of the paper. The number of migrated articles other experts is shown in Table 1. The *Outgoing* numbers refer to the group the papers were assigned to first, the *Incoming* number in the matrix refers to group which finally evaluated the papers.

Table 1.

Re-distribution of articles according to their scientific field and groups based on the search query.

	Incoming									
Outgoing		Governance	C and N compounds	Soil	Climate	Biodiversity	Water	Assessment	Other	Sum
	Governance		0	0	0	2	0	2	0	4
	C and N compounds	1		5	1	5	0	0	1	13
	Soil	0	2		0	11	0	0	3	16
	Climate	0	0	0		8	0	0	1	9
	Biodiversity	15	0	1	0		2	11	9	38
	Water	0	1	0	0	0		0	0	1
	Assessment	2	0	2	0	1	0		0	5
	Other	74	0	4	2	49	2	25		156
	Sum	92	3	12	3	76	4	38	14	

Further, the group *Other* (negative mask) included those articles which had different author keywords or titles than those covered by our search query. Those articles were analysed and sent to the experts to which they most likely fit after a first glance.

Some articles could not be evaluated due to several reasons (Suppl. material 2): they were not published in English, we had no access, the document type was wrong (no article or review), or they were out of topic.

The seven scientific fields we distinguished (see Fig. 1) are indicated by a combination of terms occurring in the author keywords or the title of the paper. The groups of articles were filtered using Scopus®*Advanced search* (see section *Search query*) and organised in library datafiles (see Suppl. material 3 for all articles in one datafile). For grouping, we used the following search terms with respect to the expert groups (see section *Methods*): 1) **govern*, *poli*, *institut**, 2) **carbon*, *nitr*, *ammo**, 3) **soil**, 4) **climat**, 5) **biodiv*, *poll*, *conserv*, *pest**, 6) **water**, 7) **assess*, *cultur***.

Adapted Delphi process

To safeguard a prevailing and coherent evaluation of the analysed articles, we chose an adapted Delphi process. The Delphi method is a technique involving a group of experts to evaluate complex issues with a dynamic communicative process (Häder and Häder 1995, Hsu and Sandford 2007). It consists of multiple assessment rounds during which the expert consultation is repeated until a certain convergence is reached. After each round information is exchanged giving the experts a chance to correct their opinions and to make the assessment more reliable. The method is used in areas where the available knowledge and data are uncertain or incomplete. Therefore, the method is also used in research for environmental assessment (Curtis 2004, MacMillan and Marshall 2006, Scolozzi et al. 2012, Uthes and Matzdorf 2016).

For our adapted Delphi process, an interdisciplinary author group of 14 researchers acted as experts. Despite from the conventional Delphi process (having one expert group) our experts were grouped according to their core research topics in seven different groups, plus *Others*. The groups were:

1. Governance
2. C and N compounds
3. Soil
4. Climate
5. Biodiversity
6. Water
7. Assessment

Each expert contributing to the meta-analysis (Suppl. material 1) reviewed papers belonging to their research area and categorised them according to one or several of the ES types specified in *CICES*, differentiating *Provisioning*, *Regulation & Maintenance*, as well as *Cultural* ES.

The experts evaluated the level of ES concept implementation with *not implemented*, *slightly implemented* or *fully implemented* for each paper. In the first round of the adapted Delphi process (see below) the following categories were applied: *not implemented*, if ES are mentioned in a paper, but the concept is not implemented; *slightly implemented*, if the ES method is implemented, but has no value for implication; *fully implemented*, if ES implications are given in relative, absolute, or monetary values.

In the agricultural context, it is also important to be clear about the relationship of agriculture to ES. In coherence with Matzdorf and Müller (2016), three different perspectives were identified and therefore evaluated by the experts: *agriculture causes negative effects*, *agriculture as a user of ES*, and *agriculture as a supplier of ES*. As the ES approach is ideally holistic, there was also the possibility to choose *several*.

To potentially find agglomerations or gaps in the global spatial distribution of research activities, the scale and the geographic allocation of the study area were investigated. Therefore we differentiated between *local, regional*, and *global* study scope. The world region classification is aligned with common comprehensive global statistics (United Nations Statistics Division 2014, FAOSTAT 2015) and differentiate *Asia, Australia and New Zealand, Europe, Latin America, Middle East and North Africa, North America*, and *Sub-Saharan Africa*.

After a first evaluation round we held a full-day moderated workshop i) to inform all experts about the evaluations from other experts, ii) to discuss all experts' experiences with the evaluation process, and iii) to refine the common understanding of the ES-based research as a basis for the second evaluation round.

The development of an improved common understanding of ES-based research was supported by a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. After this workshop the following descriptive criteria guided the evaluation of ES implementation for each paper. The improved ES concept follows the following criteria:

- Supports holistic analysis of ecosystems
- Supports interdisciplinary perspectives on ecosystems including collaboration of natural and social science
- Helps research to focus more on linkages between ecosystems and human benefits rather than on new insights in the understanding of ecological processes
- Guides research towards the use of a broad variety of methods including combinations of qualitative and quantitative methods
- Inspires natural scientists to think about the societal relevance of their research and thus, research results are often used to discuss land use management options and governance approaches.

All papers were re-evaluated in a second round using these creteria. The amount of papers with changes regarding the ES implementation are documented in Table 2.

Table 2.

Changes in the evaluation of Ecosystem Service implementation during the Delphi process

	ES implementation after Delphi II				
ES implementation before Delphi II		not implemented	slightly implemented	fully implemented	Sum
	not implemented		11	7	18
	slightly implemented	9		52	61
	fully implemented	3	13		16
	Sum				95

It was made sure that no expert reviewed their own papers. The overall adapted Delphi process took place from January to November 2016.

Dataset description

Object name

Evaluation of the ES concept implementation in agricultural scientific literature

Format names and versions

CSV, RIS

Creation dates

2016-12-01

Dataset creators

The dataset was created by Martin Schmidt and Peter Weißhuhn.

Dataset contributors

Contributors to the dataset are Jürgen Augustin, Roger Funk, Kati Häfner, Hannes König, Lasse Loft, Bettina Matzdorf, Christoph Merz, Claas Meyer, Annette Piorr, Michaela Reutter, Martin Schmidt, Ulrich Stachow, Karin Stein-Bachinger, and Peter Weißhuhn.

Language

English

License

Author contributions

The authors wish it to be known that the first 2 authors should be regarded as joint First Authors.

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Supplementary materials

Suppl. material 1: Evaluation of the ES concept implementation in agricultural scientific literature

Authors: Schmidt and Weißhuhn
Data type: CSV
Filename: EvaluationOfESLiterature.csv - Download file (196.06 kb)

Suppl. material 2: Articles which were dropped out

Authors: Schmidt and Weißhuhn
Data type: CSV
Filename: EvaluationOfESLiteratureDroppedArticles.csv - Download file (15.48 kb)

Suppl. material 3: Bibliographic data file containing all articles found with the search query

Authors: Schmidt and Weißhuhn
Data type: RIS
Filename: EvaluationOfESLiteratureAllArticles.ris - Download file (2.81 MB)