Bibliometric analysis of the relationship between the Economic Valuation of the Environment and the System of National Accounts in the Green GDP calculation from 1945 to 2022

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Autor(es): Sérgio Saraiva Nazareno dos Anjos[1], Alexsandro Barreto Gois[2,3], Fátima de Souza Freire[3], Jorge Madeira Nogueira[3]

Filiação Institucional: 1) Embrapa Agroenergia; 2) Centro Universitário de Brasília; 3) Universidade de Brasília

E-mail: sergionazareno@gmail.com, prof.alexsandrobarreto@gmail.com, ffreire51@gmail.com, jmn0702@gmail.com

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1. INTRODUCTION

In the last forty decades, several publications have sought to define, classify, and measure ecosystem services to highlight the importance of natural capital. The aim is to encourage the conservation of goods and services considered significant for humanity and relevant to social and economic well-being. The Millennium Ecosystem Assessment (MEA 2005) presented the relationship between ecosystem services and social well-being to support decision-making by political and economic agents. However, Cruz-Garcia et al. (2017) emphasize that there are studies that present the relationship between ecosystem services and social well-being, but without robust results and linked to some economic models. This fact brings up the reflection that there still needs to be more consensus on the limits a model should apply to quantify and disclose natural capital (Eigenraam and Obst 2018).

Criteria such as spatial limits, connections with other systems, and the fundamental boundaries and links between ecosystem services and human well-being can be considered essential for developing a conceptual framework that addresses the relationship between ecosystem services and social welfare (Eigenraam and Obst 2018). One of the limitations of the System of National Accounts (SNA) is the inability to integrate economic flows and variations in the stock of natural capital (environment), which limits the disclosure of socioeconomic-environmental information is the non-inclusion of the environmental system, evidencing the degradation and preservation of the environment, such as depollution activities, forest recovery, and soil regeneration, in the calculations of a socioeconomic indicator (Stiglitz et al., 2009; King et al. 2021).

To overcome or minimize these limitations, the System of Environmental-Economic Accounting (SEEA) was developed for interconnection of economic and environmental data. However, validated methodologies are scarce for including natural capital in calculating national wealth. Evidencing this scarcity is the north for the execution of this study. For this, the objective of this article is to present the state-of-the-art relationship between Environmental Economic Valuation and the SNA in scientific publications for further comprehension of the points of progress that will favor the calculations of the Green GDP.

2. THEORETICAL FOUNDATION

2.1. Natural Capital

An asset is a right that can produce economic benefits from past events expressed in the present currency for future profit. Environmental assets refer to the ecosystems, their biodiversity, live or dead, and their services to provide human well-being and survival (*e.g.*, plant pollination by bees and leisure). Therefore, these assets have unique characteristics whose accounting recognition procedures raise doubts (Anjos and Issifou 2022).

With the continuation of scientific research to provide better concepts and methods for better accounting recognition of environmental assets, the term "natural capital" was created. It is based on the principles of economics, being a recent and emerging concept of the environment, which develops in systems (ecosystems) and does not fit into a marginal analysis; this requires metrics and evaluation methods that reflect their actual condition in economic systems and extrapolate the measurability of flows of ecosystem services (Barbier 2019; Helm 2019; Mace

2019). Thus, the monetary value attributed to natural capital can generate reserves and industrial applications for the future (Nogueira et al. 2000).

Assuming that only what is quantified is measured, the quantification and disclosure of natural capital are necessary to achieve the proposal of this work, including considering the depletion of natural capital to support the calculation of the Green GDP. Ratifying Boyd (2007), possibly for this, one of the most important instruments that the economic literature makes available is the economic valuation of the environment.

2.2 Economic Valuation of the Environment (VEMA)

The economic valuation of environmental assets quantifies ecosystem services and biodiversity in monetary value. Doing so is a strategic and necessary mechanism to show the relevance of the environment to society and the consumer market (Baveye et al. 2013), contributing to its preservation and rational use (Nogueira et al. 2000). Therefore, natural capital becomes a measurable asset and can be included in national accounts (Dasgupta 2021).

The pricing of biodiversity and ecosystem services is a challenge for world science as it is outside official foreign trade statistics (there are no codes that promote the distinction of biodiversity assets from fossil assets, for example) (Silva et al. 2018). In this context, the economic valuation of the environment tends to be necessary to include the environmental perspective in the SNA, in other words, to adjust the GDP that we currently know into the Environmental Economic Accounts integration. In his study, Anjos (2020) pointed out the importance of valuing and pricing biodiversity assets to subsidize conservation regulation and undo market distortions; this represents a paradigm shift from predatory use to a sustainable model (Andrade 2017).

2.3 National Accounts System and System of Environmental-Economic Accounting

The essence of the SNA procedures is based on a Keynesian macroeconomic model, including elements of the microeconomic theories of general equilibrium and well-being (Mueller 2012). According to Mueller (2012), although the SNA provides a consolidated set of aggregated indicators with consistency and solidity, it must be considered that there is a significant deficiency (or omission) of the system in recording the impacts of the economic system on the environment. In a complementary way, Feijó and Ramos (2017) go into greater detail

concerning this criticism and mark that the national accounts omit or fail to include several activities that do not have a market value, including depletion of natural resources and that reiterate the explanation of Nogueira et al. (2000) in the last section. Young et al. (2018) comment that one of the alternatives to solve the absence of the calculation of activities that do not have a market value, such as the depletion of natural resources, would be the construction of satellite accounts, such as Portugal's successful case by the development of a satellite account for blue economy (Gois and Nogueira 2025a).

One of the new actions was the development of the System of Economic-Environmental Accounting (SEEA), which brought some discussions on the main aspects of this system: treatment of depletion (depreciation) of natural capital; treatment of the costs of environmental degradation generated by the economy; and costs of preventing and defending against the effects of environmental degradation. In this sense, as a response to the deficiency of the SNA, due to the limitations of information only from the economic system, in an isolated way, the SEEA aims to include data and environmental information in the SNA through the environmental satellite accounts, integrating the economic and environmental systems.

2.4 Application of VEMA in SEEA development

New production boundaries to balance environmental processes with human or economic processes must be reconsidered to integrate ecosystem services into SNA and extrapolate the production boundary of GDP to obtain the Green GDP (Obst et al. 2016). Therefore, the biggest challenge for developing the SEEA is identifying the most appropriate methodology, integrating ecosystem resources into the SNA, and identifying and recognizing biodiversity, ecosystems, and ecosystem services as the country's natural capital.

Gois and Nogueira (2020) and King et al. (2021) suggested using economic valuation methods to incorporate the environmental assets into SEEA calculation and further use for Green GDP. Comte et al. (2022) reinforce the valuation methods as mechanisms to apply a monetary value to ecosystem services that could make it easier to construct and manage public policies to protect ecosystems and their sustainable industrial use. Economic valuation techniques can insert biodiversity into economic systems, generate data for application in SEEA, and obtain monetary values consistent with SNA principles (King et al. 2021; Pelletier et al. 2021). In addition, economic valuation allows the articulation of biodiversity, ecosystem services, and

benefits generated in a broad view, such as that of an invasive species that can enhance pollination in each ecosystem (King et al. 2021).

3. METHODS AND PROCEDURES

The research is bibliographic and documentary using scientific publications retrieved on the Web of Science database (WoS) by Clarivate Analytics and accessed on April 21st, 2022. The temporality of the research execution was between 1945 and April 21st, 2022, and the indicators used were: years of publication, WoS categories (scientific areas), countries, institutions, authors, journals, and citations.

The search was performed by combining keywords in English that encompass GDP, valuation, and accounting in the "Topic" field with Boolean operators "AND" to search for documents that integrate the search words and "OR" to search for variations in GDP indexing, and the wildcard character "asterisk" (*) was also used to include spelling variations in search terms and increase the number of documents retrieved. Therefore, the search strategy was: “valuat* (Topic) AND account* (Topic) AND (GDP OR "gross domestic product") (Topic)”. VantagePoint (Search Technology) software was used for mining and processing bibliometric data, that permits crossing, and decomposing data to allow better visualization and interpretation (Miles et al. 2016).

4. RESULTS AND DISCUSSION

The total number of documents retrieved was 106, of which only 4 refer to the Green GDP: Holub et al. (1999), Boyd (2007), Li and Fang (2014), and Yuan et al. (2017).

Even with the temporality of the search starting in 1945, the first article retrieved was published by Ivanov et al. in 1993, that described the deployment of the SNA in the Commonwealth of Independent States republics. Between 1993 and 2006, some publications and numbers increased from 2007 onwards. According to Baveye et al. (2013), the theme "monetization of ecosystem services" was officially launched in 1997, which is like the findings of this study and confirms that the use of economic valuation methods for ecosystems and their services is recent and there are few positive experiences in the calculation of Green GDP, as pointed out by Li and Fang (2014).

The geographical distribution of publications retrieved showed papers published in all continents. The United States of America (USA), China, Germany, and the United Kingdom dominate, with the presence of countries such as Bhutan, Malta, Monaco, and Togo and low representation of BRICs countries such as Brazil, India, and Russia. It is noticeable that studies on the economic valuation of the environment and SNA in all continents are completed or in progress.

The indicators WoS categories (scientific areas), institutions, authors, journals, and citations are still in analysis. The preliminary results show that the WoS categories “Economics” and “Environmental Sciences” have equal importance and are connected to Ecology. Figueiredo (2016) points out the interdisciplinarity and multidisciplinarity of Environmental Sciences from the influence of external contexts of environmental and scientific management, which reflects the evolution of Sustainable Development over the years, and which culminated in important documents such as the Brundtland Report, the CBD, the Paris Agreement and the Nagoya Protocol.

Holub et al. (1999) and Boyd (2007) highlighted the incompatibility of economics and environmental sciences on spatial and time scales in the period of the publication of their papers. At the time, there were no valuation methods for adapted environmental assets. Furthermore, the few macroeconomic aggregates suitable for the environmental context resulted in a reduction of the analytical potential of the accounting system for the inclusion of environmental indicators (Holub et al. 1999), which is still a scientific lack (Gois and Nogueira 2025b). This scenario made the SEEA inappropriate for use on Green GDP at that period, according to economists' inability to include ecosystem services on accounts (Boyd 2007).

There still are scientific gaps in the association of valuation methods used to give ecosystem services a monetary value to reflect the real national wealth (Comte et al. 2022). However, the temporal gap between Holub et al. (1999), Boyd (2007), Li and Fang (2014), and Yuan et al. (2017) present different interpretations of the theme discussed in the paper in different decades and shows the evolution of research to obtain a trustworthy GDP better and for better connection to each country's social, economic and environmental situations.

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