

Environmental Economic Valuation and the System of National Accounts for Green Gross Domestic Product calculation: a bibliometric analysis between 1945 and 2022

Sérgio Saraiva Nazareno dos Anjos
PhD in Environmental Sciences, University of Brasília (UnB)
<https://orcid.org/0000-0003-3723-351>
E-mail: sergio.saraiva@embrapa.br

Alexsandro Barreto Gois
PhD in Economics from the University of Brasília (UnB)
<https://orcid.org/0000-0003-4303-6428>
E-mail: alexsandro.gois@cnpq.br

Fátima de Souza Freire
Full Professor at the Department of Accounting, University of Brasília (UnB)
<https://orcid.org/0000-0003-1133-5087>
E-mail: ffreire@unb.br

Jorge Madeira Nogueira
Full Professor at the Department of Economics, University of Brasília (UnB)
<https://orcid.org/0000-0002-3772-7145>
E-mail: jmn0702@gmail.com

DOI: 10.18829/2317-921X.2025.e60190

Abstract

This article is a theoretical essay that presents the state-of-the-art relationship between Environmental Economic Valuation and the System of National Accounts (SNA), unifying accounting, and economic elements to develop future indicators for Green Gross Domestic Product (Green GDP) calculation. Several studies have emerged to define, classify, and measure ecosystem services in recent decades. Nevertheless, there are still gaps in the quantification and disclosure of natural capital. The quantification of natural capital is essential in the System of Environmental-Economic Accounting (SEEA). By including environmental information in the traditional SNA, the SEEA makes it possible to estimate macroeconomic aggregates more rigorously for the Green GDP. Methods and procedures are needed to make these estimates viable that allow monetary assessment of ecosystem goods and services that do not have a market price and the depletion or depreciation of the stock of resources that make up the national ecological heritage. This paper is exploratory and quantitative research based on a bibliometric analysis of scientific publications on GDP, Green GDP, and economic valuation from 1945 to 2022, prospected on the Web of Science database. There are publications on the proposed theme on all continents, emphasizing Europe, Asia, North America, and Africa, and the low representation of South America. There are a predominance of universities and Research and Development (R&D) organizations among the institutions. Some retrieved documents are papers published by institutions that do not develop R&D activities like the

financial system, showing interest in the subject aiming for competitiveness in its market. There is a need for further research to develop and validate indicators to obtain Green GDP, including the natural capital. The ratification of several international agreements and protocols related to the environment also can stimulate the application of economic valuation methods to guarantee the adequate inclusion of environmental assets in the calculation of national wealth.

Keywords: Environmental Accounting; Natural Capital; System of Environmental-Economic Accounting.

Resumo

Este artigo é um ensaio teórico que apresenta o estado da arte da relação entre a Valoração Econômica Ambiental e o Sistema de Contas Nacionais (SCN), unificando elementos contábeis e econômicos para desenvolver indicadores futuros para o cálculo do Produto Interno Bruto Verde (PIB Verde). Diversos estudos surgiram para definir, classificar e mensurar os serviços ecossistêmicos nas últimas décadas. No entanto, ainda existem lacunas na quantificação e divulgação do capital natural. A quantificação do capital natural é essencial no Sistema de Contas Econômicas Ambientais (SEEA). Ao incluir informações ambientais no SCN tradicional, o SEEA possibilita estimar agregados macroeconômicos com mais rigor para o PIB Verde. Métodos e procedimentos são necessários para viabilizar essas estimativas que permitam a avaliação monetária de bens e serviços ecossistêmicos que não possuem preço de mercado e o esgotamento ou depreciação do estoque de recursos que compõem o patrimônio ecológico nacional. Este artigo é uma pesquisa exploratória e quantitativa baseada em uma análise bibliométrica de publicações científicas sobre PIB, PIB Verde e valoração econômica de 1945 a 2022, prospectadas na base de dados *Web of Science*. Há publicações sobre o tema proposto em todos os continentes, com ênfase na Europa, Ásia, América do Norte e África, e a baixa representatividade da América do Sul. Há predominância de universidades e organizações de Pesquisa e Desenvolvimento (P&D) entre as instituições. Alguns documentos recuperados são artigos publicados por instituições que não desenvolvem atividades de P&D como o sistema financeiro, demonstrando interesse no tema visando competitividade em seu mercado. Há necessidade de mais pesquisas para desenvolver e validar indicadores para a obtenção do PIB Verde, incluindo o capital natural. A ratificação de diversos acordos e protocolos internacionais relacionados ao meio ambiente também pode estimular a aplicação de métodos de valoração econômica para garantir a inclusão adequada dos ativos ambientais no cálculo da riqueza nacional.

Palavras-chave: Contabilidade Ambiental; Capital Natural; Sistema de Contabilidade Ambiental-Econômica.

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 definitions, classifications, and measurements of ecosystem services follow the 17th Convention for the Protection of World, Cultural, and

Natural Heritage precepts held in 1972 by the General Conference of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

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; 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; Obst, 2018). Despite its relevance, the result of a conceptual framework is beyond the scope of this article. Our focus here is to highlight the state-of-the-art relationship between the Economic Valuation of the Environment and the System of National Accounts (SNA) from a bibliometric analysis.

The SNA has limitations that have been widely analyzed by several economists, emphasizing the referenced study by Stiglitz, Sen and Fitoussi (2009) for the French government. One of them is the inability to integrate economic flows and variations in the stock of natural capital (environment). For example, in a first analysis, the Gross Domestic Product (GDP) measures the final goods and services produced in an economy at a specific time, characterized as a flow indicator. However, to generate wealth flows, we can degrade wealth stocks (an area of natural vegetation), reducing their economic value. Thus, one of the issues that limit 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 and decontamination activities, forest recovery, and soil regeneration, in the calculations of a socioeconomic indicator (King et al., 2021).

To overcome or minimize these limitations, the System of Environmental-Economic Accounting (SEEA) was developed. SEEA is a National Accounting standard for the interconnection of economic and environmental data. For example, the Green GDP must quantify and qualify the natural ecological heritage, that is, measure the wealth of a nation's

natural capital, thus being an indicator of stock. Realizing this distinction, the SEEA must consider this particularity for possible integration with the SNA.

The SEEA uses the principles adopted in measuring the standardization of the economic system in all countries. 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.

The results of this study can be data-driven to identify scientific gaps to further development and implementation of efficient policies towards economic growth and environment preservation. This combination is also an important path for expansion of the SEEA worldwide implementation.

2. Theoretical foundation

The Convention on Biological Diversity (CBD), established at the United Nations Conference on Environment and Development (UNCTAD), also called "Rio-92" and that took place in Rio de Janeiro in June 1992 has three fundamental pillars: the conservation of biological diversity, the sustainable use of biodiversity, and the fair and equitable sharing of benefits arising from the use of genetic resources (UN, 1992). In this context, the CBD also incorporates social issues with traditional communities¹ (Thorstensen; Mota, 2021). As a result, the convention is considered one of the most important international environmental instruments and the first legal framework for biodiversity in some countries (Chandra; Idrisova, 2011).

The integration of ecosystems in the planned actions of the public and private sectors meets the goals established both in the Convention on Biological Diversity (CBD) and in the Sustainable Development Goals (SDGs) of the 2030 Agenda, in particular SDGs 2 (zero hunger), SDG 9 (industry, innovation, and infrastructure), SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land). The mentioned SDGs allow us to verify

¹ According to item I of paragraph 3 of Decree No. 6,040, of February 7th, 2007, traditional communities are culturally differentiated groups that are recognized as such, that have their own forms of social organization, that occupy and use territories and natural resources as a condition for their cultural, social, religious, ancestral, and economic reproduction, using knowledge, innovations and practices generated and transmitted by tradition (Brazil, 2007).

that the goals involved link ecosystems (SDG 13, SDG 14, SDG 15) to society (SDG 2) and the economy (SDG 9, SDG 11, SDG 12) that are funneled in SDG 17 (partnerships and means of implementation) (Gois; Issifou; Anjos, 2022).

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; 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; Medeiros; Arruda, 2000). However, Martins (2021) highlights that the concept of natural capital only as raw material for industrial processes neglects its indirect use, quasi-option, and existence values, generating the need for a better definition of methods for financial measurement.

The link between biodiversity and different ecosystems, in various stages of conservation and with the socioeconomic variety found worldwide, constitutes a great challenge that requires a complex integration process. This link aims to achieve efficient management of ecosystems, aligning economic development with the rational use of natural capital; this is because ecosystem management aims to sustain the flow of services provided to society and is aligned with the sovereignty of the country in its natural capital, according to the CBD and the Nagoya Protocol, a supplementary document to the CBD that reinforces such sovereignty (Thorstensen; Mota, 2021).

This work proposes the connection between the conservation of biological diversity and the sustainable use of biodiversity, associated with the pillars of the convention, as both are fundamental for maintaining human life on Earth. 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 reflects 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; Baveye; Gowdy, 2013), contributing to its preservation and rational use (Nogueira; Medeiros; Arruda, 2000). Therefore, natural capital becomes a measurable asset and can be included in national accounts (Dasgupta, 2021).

Smesaert, Missemmer and Levrel (2020) include valuation as a process of commoditization and conversion of goods and services into marketable products. Hahn et al. (2015) reinforces this concept by pointing out that there was an expansion in the use of economic tools that allowed the scaling up of funding for biodiversity. The signing of the CBD in 1992 and the publication of legal frameworks such as Law # 13,123/2015 in Brazil reinforce the inclusion of economic exploitation and the applicability of methods that allow obtaining monetary values of intermediate or final products from access to native genetic heritage. In his study, Anjos (2020) detected 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).

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; Pereira; Martins, 2018). This fact causes a mistaken and subjugated perception of the economic importance of biodiversity. Therefore, it induces market failures by imputing values with empirical methods and concepts that do not apply to reality (Nogueira; Medeiros; Arruda, 2000), in addition to enabling a better measurement of abiotic impacts (rain, drought, cold, heat, for example) with economic indicators of biodiversity (King et al. 2021).

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. Thus, through the economic valuation of the environment, it is possible to attribute qualitative and quantitative value to environmental resources, contributing to the calculation of the Green GDP (Gois; Nogueira, 2020). Also, the depletion (or depreciation) of the natural capital must be valued to be considered in the System of Environmental-Economic Accounting (SEEA) calculation as a reducer of the natural ecological heritage.

2.3 National Accounts System and System of Environmental-Economic Accounting

The SNA was established under the leadership of the UN and adopted for calculating macroeconomic aggregates, including GDP. As a result, the SNA generates several indicators that can guide, assess, and manage the economic growth of a nation (Mueller, 2012). In particular, the GDP calculation is used by all countries to measure the production of goods and services in a given place in a fiscal year, as national accounts were developed to provide an overview of the state of the economy over a while.

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). Thus, national accounts have limitations, such as the fact that the assessment of a nation's economic and social well-being must consider not only activities that have a market value but must consider activities without market value.

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, regarding the macroeconomic aggregates considered for the measurement of GDP, 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, Medeiros and Arruda (2000) in the last section. Feijó and Ramos (2017) also comment that the GDP calculation includes things that do not make a country more prosperous. For example, it increases with polluting activities that deplete the stock of natural resources.

Young, Pimenteira and Almeida (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. In doing so, the conventional GDP calculation metric would remain unchanged, adding environmental information on the depletion of natural resources as a form of GDP adjustment. An alternative would be the complete formulation of new information on aggregation systems that would not be restricted to transactions of an economic nature.

In this sense, returning to the criticism of GDP, it is a macroeconomic indicator that measures the productivity of economic activity. Nevertheless, it does not measure the wealth of natural ecological heritage through quantifying and disclosing natural capital. The GDP reflects, in its composition, the degradation of this heritage, considering that to produce goods and services, it is necessary to use natural capital, which causes the depletion of the natural ecological heritage (Mueller, 2012; Young; Pimenteira; Almeida, 2018).

With the development of GDP analysis, it became evident that macroeconomic aggregates hide costs and treat expenditures associated with environmental regeneration, protecting individuals and families from the effects of environmental degradation as income, therefore, as an indicator of well-being. Furthermore, the asymmetric treatment given to elements of a country's heritage, such as built capital (factories, machines, vehicles, buildings), whose variation is carefully monitored by the SNA, and natural capital (natural resources such as soils, mineral reserves), whose variation is not registered by the system (Mueller, 2012).

Considering that the SNA treats the economy as an isolated system in which transactions do not interact with the environment, ignoring the impacts of production and consumption activities. Because of this, it generates indicators and aggregates that provide a distorted view of what happens in the economic system, with deficiencies and omissions in the system, as Mueller (2012) relates:

1. The SNA ignores the depreciation of the economy's natural capital stock.
2. The SNA does not consider the costs of environmental degradation.
3. The expenses resulting from environmental degradation are included in the economy's GDP.

The deficiencies above reduce the importance of macroeconomic aggregates, which do not show the impact of the economic system on the environment. Therefore, different actions

were initiated to review the methodologies and practices of the current SNA to correct these flaws.

In the mid-1980s, studies were carried out to reform the SNA to include aspects of the environmental dimension, developed jointly with the United Nations Statistical Office, the World Bank, and statistical organizations in some countries. In these studies, it is concluded that an auxiliary system should be developed, with a set of environmental satellite accounts, to be coupled to the central core of the SNA, which allows the generation of aggregate indicators that capture aspects of the relations of the economic system with the environment. In this way, the System of Economic-Environmental Accounting (SEEA) emerged, which brought some discussions on the main aspects of this system:

1. treatment of depletion (depreciation) of natural capital.
2. treatment of the costs of environmental degradation generated by the economy.
3. 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.

From the discussions held by the World Commission on Environment and Development in 1987 (UN; WCED, 1987), studies were carried out and brought proposals that were approved and adopted, such as the creation of the Integrated System of Economic and Environmental Accounting (SICEA) of the UN in 1993. It was updated in 2003, and the last version of this methodology was published in 2012, known as SEEA, which generated a UN framework that integrates economic and environmental data to provide a more comprehensive and multifunctional view of the interrelationships between the economy, the environment and stocks and changes in stocks of environmental assets, contributing benefits to humanity (Barcellos; Carvalho, 2018).

2.4 Application of VEMA in SEEA development

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. For example, Joly et al. (2011) pointed out the necessary relationship between biodiversity and ecological

processes to valuation mechanisms and valorization of ecosystem services as a form of preservation and rational use.

King et al. (2021) reinforce the issue by pointing out the importance of considering gamma diversity and extrapolating changes in the occurrence of species in different places and times in the development and application of indicators that will encourage the calculation of the Green GDP in addition to allowing the inclusion of social indicators. Therefore, new production boundaries to balance environmental processes with human or economic processes must be reconsidered to integrate ecosystem services to SNA and extrapolate the production boundary of GDP to obtain the Green GDP (Obst; Hein; Edens, 2016).

The ecosystem services and the impact on human well-being are the standards of the SEEA. Therefore, the first step is quantifying physical flows from environmental assets to its clients and beneficiaries (Pelletier; Heagney; Kovač, 2021). At this point, 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; Heagney; Kovač, 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 an ecosystem (King et al., 2021).

The advantages of the economic valuation methods of the environment are evident. However, deficiencies and limitations still reduce their application in the calculation of the Green GDP with the inclusion of environmental indicators in the calculation of GDP (Hoff et al., 2021). At this point, Daly and Cobb (1989), mentioned by Li and Fang (2014), comment that the current SNA treats ecosystems as a "business in liquidation." As a result, the usual methods of calculating the Green GDP do not incorporate environmental sustainability as they ignore the benefits generated by ecosystem services to society, and successful experiences are specific and regional in scope (Li; Fang, 2014).

Yuan, Lo and Yang (2017) confirm the indication by King et al. (2021) when stating that the valuation of ecosystem services would generate essential proxies for calculating the Green GDP. However, Li and Fang (2014) point out the low number of scientific studies that relate the integration of the valuation of environmental assets with the usual economic and accounting precepts, which generates gaps due to the lack of reliable data and measures. Therefore, the development of a dashboard of indicators is important to encourage countries to adopt valuation techniques to obtain the real monetary value of ecosystems for a better

calculation of Green GDP, to engage public policies, and to develop economic and accounting definitions of sustainability (Comte et al., 2022).

3. Methodology

The research is bibliographic and documentary using scientific publications retrieved on the Web of Science database (WoS) by Clarivate Analytics and accessible through the site "Periódicos da CAPES"² 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 scientific areas refer to the WoS indexing areas for each publication inserted in the database, which can facilitate the necessary filtering and assess some degree of multidisciplinary in the search. The WoS option for the search was made because it is the oldest database, with publications from 1945 onwards, for having a *template* that favors the detailing of the indicators to be used and for creating extra keywords that increase the retrieval of scientific publications.

The search was performed by combining keywords in English that encompass GDP, valuation, and accounting in the "Topic" field, which allows combining searches in titles, abstracts, authors' keywords, and extra keywords that WoS inserts. Each search term was combined using the 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. The search was then redone, changing the term GDP to "Green GDP" to compare this result with the macro search. In both searches, grey literature, such as institutional reports, working papers, government documents, dissertations, theses, and proceedings of technical-scientific events, were excluded from the corpus to mitigate potential biases of the possible lack of scientific accuracy (Cui; Zhang, 2024) (Figure 1)

² Foundation linked to the Brazilian Ministry of Education, whose initials means "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, or "Coordination for the Improvement of Higher Education Personnel" in English.

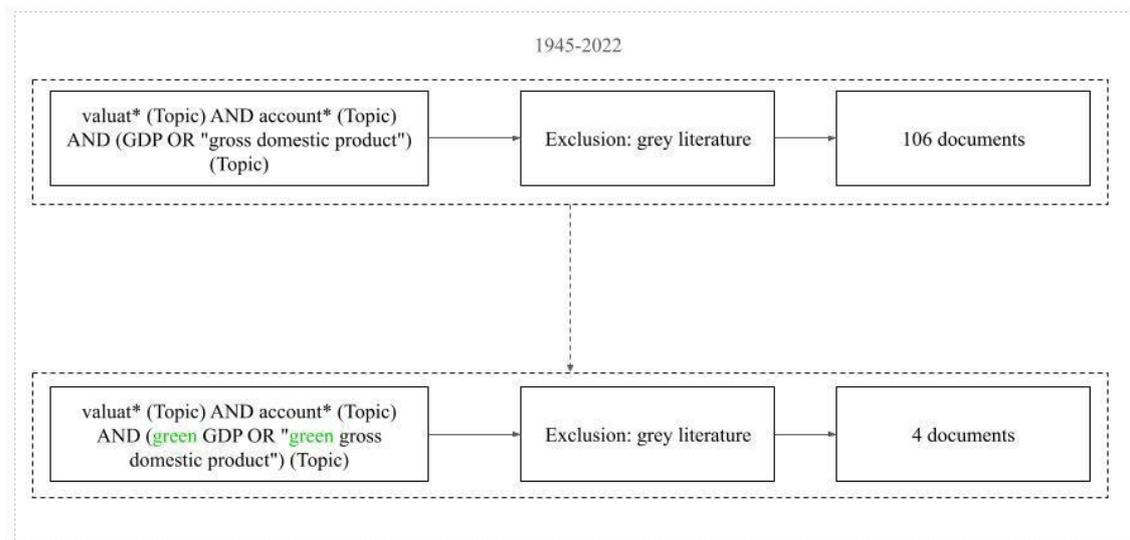


Figure 1: Search protocol. Source: Own elaboration.

One of the advantages of WoS is the compatibility of recovered data with VantagePoint (Search Technology) and VOS Viewer (Leiden University) softwares for mining and processing bibliometric data. Raw data were extracted and processed in VantagePoint, which allows mining, cleaning bibliometric data extracted from databases such as WoS, crossing, and decomposing data to allow better visualization and interpretation (Miles; Saritas; Sokolov, 2016). VOS Viewer analyzes raw data extracted from databases and uses algorithms that organize the information into clusters by the distance between the data and the size of the figure corresponding to the numerical representation of each data (Miles; Saritas; Sokolov, 2016; Smesaert; Missemer; Levrel, 2020).

4. Results and discussion

The results of searches for scientific publications are described in Table 1.

Table 1: Result of the bibliometric search

Search strategy	Temporality	Number of documents retrieved
valuat* (Topic) AND account* (Topic) AND (GDP OR "gross domestic product") (Topic)	1945-2022	106

<p>valuat* (Topic) AND account* (Topic) AND ("green GDP OR "green gross domestic product") (Topic)</p>	<p>1945-2022</p>	<p>4</p>
--	------------------	----------

Source: Own elaboration.

The number of documents that refer to the Green GDP represents only 3.77% of the total documents retrieved in the broader search, where the four publications are contained (Table 2):

Table 2: Result of the bibliometric search using "green GDP" or "green gross domestic product" in the search strategy

Authors	Institutions	Country	Title	Periodical	Year of Publication
Hans Werner Holub, Gottfried Tappeiner, Ulrike Tappeiner (Holub; Tappeiner; Tappeiner, 1999)	University of Innsbruck	Austria	Some remarks on the System of Integrated Environmental and Economic Accounting of the United Nations	Ecological Economics	1999
James Boyd (Boyd, 2007)	Resources for the Future	USA	Nonmarket benefits of nature: What should be counted in green GDP?	Ecological Economics	2007
Guangdong Li, Chuanglin Fang (Li; Fang, 2014)	Chinese Academy of Sciences; University of Chinese Academy of Sciences	China	Global mapping and estimation of ecosystem services values and gross domestic product: A spatially explicit integration of national 'green GDP' accounting	Ecological Indicators	2014

Mei-Hua Yuan, Shang-Lien Lo, Chih-Kai Yang (Yuan; Lo; Yang, 2017)	National University	Taiwan	Taiwan	Integrating ecosystem services in terrestrial conservation planning	Environmental Science and Pollution Research	2017
---	---------------------	--------	--------	---	--	------

Source: Own elaboration.

Baveye, Baveye and Gowdy (2013) reported the development of works that refer to the economic valuation of ecosystem services from Ancient Greece, with Plato's perceptions about the relationship between deforestation of forests, soil erosion, and drier springs. From the end of the 1940s onwards, works were published that proved human dependence on the environment, and market distortions, such as those by the Romanian economist Nicholas Georgescu-Roegen.

Even with the temporality of the search starting in 1945, the first article retrieved was published in 1993. Ivanov et al. (1993) 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 (Figure 2). According to Baveye, Baveye and Gowdy (2013), the theme "monetization of ecosystem services" was officially launched in 1997, which is similar to 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).

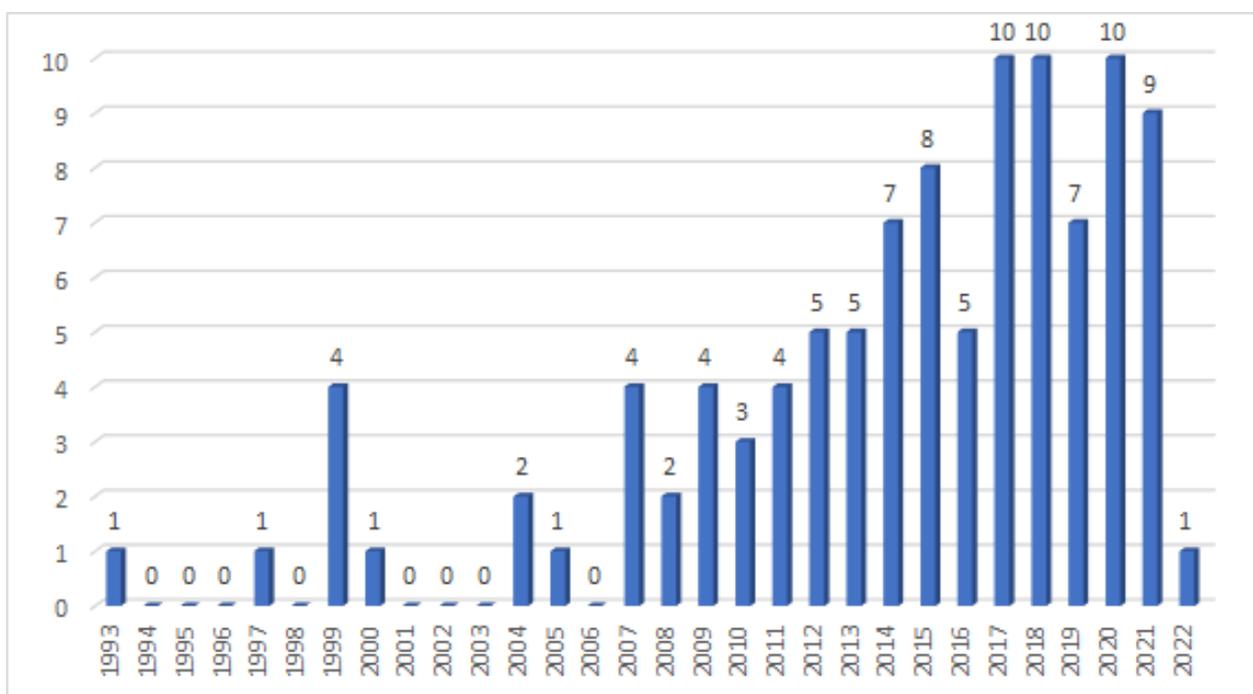


Figure 2: Years of publication of the 106 retrieved documents. Source: Own elaboration.

Table 3 presents the scientific areas with more than one occurrence on the retrieved documents. These areas are WoS categories divided into five groups (Arts & Humanities, Life Sciences & Biomedicine, Physical Sciences, Social Sciences, and Technology) that index and

categorize the documents on the database important for further analysis (CLARIVATE ANALYTICS, 2025).

Table 3: Web of Science categories of the documents retrieved

Ranking	# Records	Web of Science Category
1	49	Environmental Sciences
2	43	Economics
3	13	Ecology
4	11	Business, Finance
5	5	Engineering, Environmental
6	5	Forestry
7	5	Green & Sustainable Science & Technology
8	5	Public, Environmental & Occupational Health
9	4	Business
10	4	Multidisciplinary Sciences
11	3	Agricultural Economics & Policy
12	3	Meteorology & Atmospheric Sciences
13	2	Biodiversity Conservation
14	2	Energy & Fuels
15	2	Health Policy & Services
16	2	International Relations
17	2	Management
18	2	Oceanography
19	2	Social Sciences, Interdisciplinary
20	2	Urban Studies
21	1	Critical Care Medicine
22	1	Development Studies

Ranking	# Records	Web of Science Category
23	1	Engineering, Chemical
24	1	Entomology
25	1	Ergonomics
26	1	Food Science & Technology
27	1	Health Care Sciences & Services
28	1	Infectious Diseases
29	1	Marine & Freshwater Biology
30	1	Materials Science, Multidisciplinary
31	1	Neurosciences
32	1	Nursing
33	1	Obstetrics & Gynecology
34	1	Parasitology
35	1	Pediatrics
36	1	Political Science
37	1	Psychiatry
38	1	Regional & Urban Planning
39	1	Respiratory System
40	1	Social Issues
41	1	Transportation
42	1	Tropical Medicine
43	1	Water Resources

Source: Own elaboration.

Figure 3 presents the autocorrelation map between the WoS categories with more than one occurrence (1st to 20th positions on Table 3's ranking). This map presents the correlations between scientific areas of the documents retrieved in the search. The size of each circle

represents the number of documents, and the thickness of the lines represents the degree of correlation.

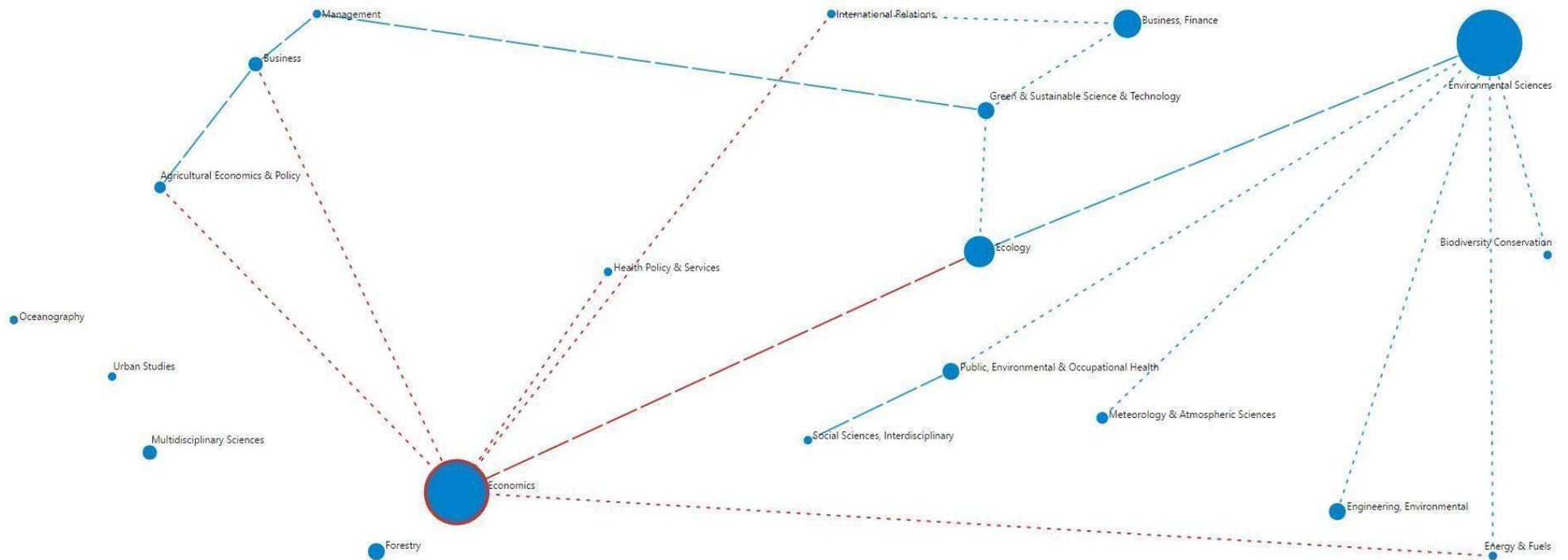


Figure 3: Autocorrelation map constructed on VantagePoint software between Web of Science categories on Table 3, with highlights on the Economics scientific subject. Source: Own elaboration

Economics and Environmental Sciences have equal importance and powerfully connect to Ecology. This information confirms what Boyd (2007) reinforced: ecosystem services, which Ecology can represent, are a consistent point of contact between Economics and Environmental Sciences.

Other essential connections include Business, Management, Agricultural Economics & Policy, and Management and Green & Sustainable Science & Technology. These connections make part of the theoretical basis for Green GDP calculation. Oceanography, Urban Studies, and Forestry do not have any connections; this confirms that most of the scientific publications retrieved do not include WoS categories that include the ecosystems and their services, which confirms the low number of documents about Green GDP shown in Table 1 and 2. Li and Fang (2014) signaled the lack of data on marine ecosystems for better use for economic-environmental procedures for Green GDP and SNA, which reinforces the isolation of Oceanography in Figure 2.

Until the search and data retrieval date, only one article was published in 2022 by a Moroccan author. Sabbahi (2022) valued the ecosystem service of pollinating insects in fruit, oilseed, pulses, spices, and vegetable plantations, in different ranges of dependence on pollinating insects, using a bioeconomic model. The results show the positive impact of insects on ensuring food security and contributing to biodiversity preservation. Furthermore, the contribution of pollinators added more than US\$1.2 million to Moroccan agriculture, which represents 8.5% of the local agribusiness GDP. It also appears that the data obtained can be used to develop indicators that allow adding the gain promoted by pollinating insects to the local Green GDP.

Table 4 and Figure 4 present the distribution of publications retrieved by countries, including documents with different countries of the co-authors.

Table 4: List of publishing countries of the 106 documents retrieved, in descending order

Descending Order	Number of documents	Countries
1	30	USA
2	25	China
3	13	Germany
4	10	United Kingdom
5	8	Australia

Descending Order	Number of documents	Countries
6	6	Spain
7	5	The Netherlands
8	5	South Africa
9	4	Finland
10	4	Sweden
11	3	Canada
12	3	Denmark
13	3	France
14	3	Japan
15	3	Poland
16	3	Taiwan
17	2	Austria
18	2	Brazil
19	2	India
20	2	Italy
21	2	Norway
22	2	Portugal
23	2	Russia
24	2	Singapore
25	1	Belgium
26	1	Bhutan
27	1	Czech Republic
28	1	Georgia
29	1	Malta
30	1	Mexico

Descending Order	Number of documents	Countries
31	1	Monaco
32	1	Morocco
33	1	Mozambique
34	1	Slovakia
35	1	Tanzania
36	1	Togo
37	1	Zambia

Source: Own elaboration.

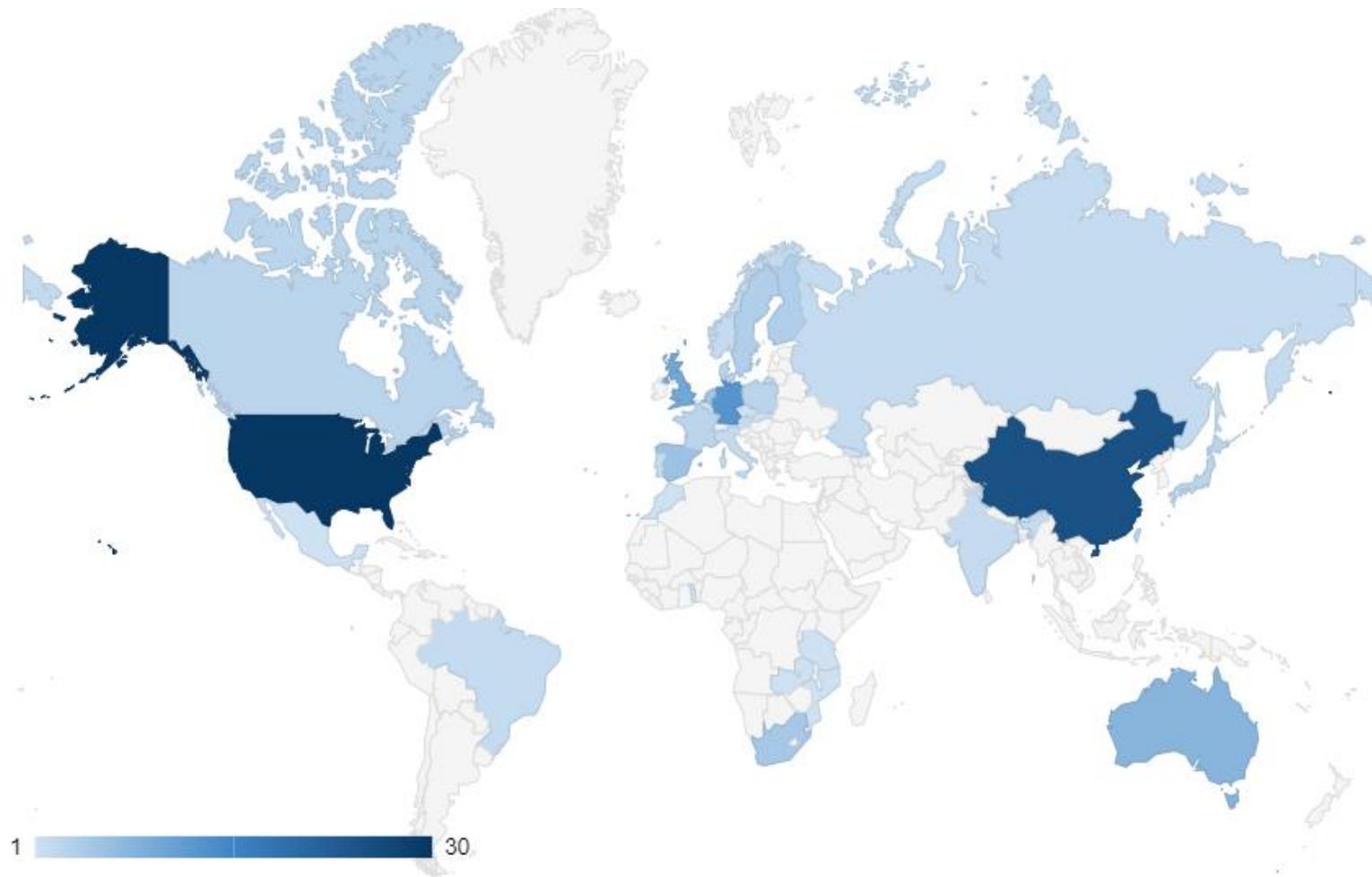


Figure 4: Countries that published the 106 retrieved documents. Source: Own elaboration.

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. It is noticeable that studies on the economic valuation of the environment and SNA in all continents are completed or in progress. There is an expressive number of documents recovered from Africa; only Brazil and Mexico represent Latin America. The 2023 Global Assessment of Environmental-Economic Accounting highlights Brazil, Mexico, Colombia, and Costa Rica as the Latin America countries who have regular compilation and national dissemination of SEEA (UN, 2025). However, Gois and Nogueira (2025) highlighted that Mexico, Brazil, Colombia, and Ecuador are the most advanced Latin American countries in Environmental Accounting for Green GDP calculation. Probably, these countries are not significant on the corpus due to possible data publication in grey literature. Types of this literature, such as government documents, dissertations, theses, and institutional reports, are not indexed in the WoS database. This fact constitutes a possible bias in this study, as it does not retrieve non-scientific documents in other languages besides English.

In Latin America and Caribe, Santoyo et al. (2025) demonstrated that Costa Rica, Guyana, and the Dominican Republic have better integration of economic and environment policies (sustainable development), with Green GDP higher than conventional GDP, while larger economies, such as Mexico and Argentina, have difficulties to connect economy and ecology. Brazil has a smaller difference between GDP and Green GDP, which means that sustainable development is more advanced (Santoyo et al., 2025). USA and China appear as countries with the higher number of publications retrieved, but their compilation and dissemination status of SEEA is lower than countries like Germany, United Kingdom, India, Brazil, Nigeria, and Indonesia, probably due to the exclusion of government documents, dissertations, theses, and institutional reports (UN, 2025).

Figure 5 presents a cluster map indicating the degree of interaction of co-author countries of the retrieved documents. The polarization of the USA, China, and Germany and, to a lesser extent, of Australia, the United Kingdom, France, and Finland are shown. There are fifteen *clusters*, of which seven are shown in Figure 5 and detailed in Table 5. The *clusters* represent polarizations between co-author countries based on groupings of their publications from the same continent, common borders or not (Van Eck; Waltman. 2014).

Table 5: Clusters shown in Figure 4

<i>Cluster</i>	Countries
1	Austria, Finland, Czech Republic, Sweden, Taiwan, Zambia
2	Denmark, Spain, Italy, Monaco, Norway, United Kingdom
3	Australia, Belgium, Bhutan, Canada, Netherlands
4	France, Mozambique, Poland, Portugal
5	USA, Japan, Mexico, Tanzania
6	China, Scotland, Singapore
7	Germany and Georgia

Source: Own elaboration.

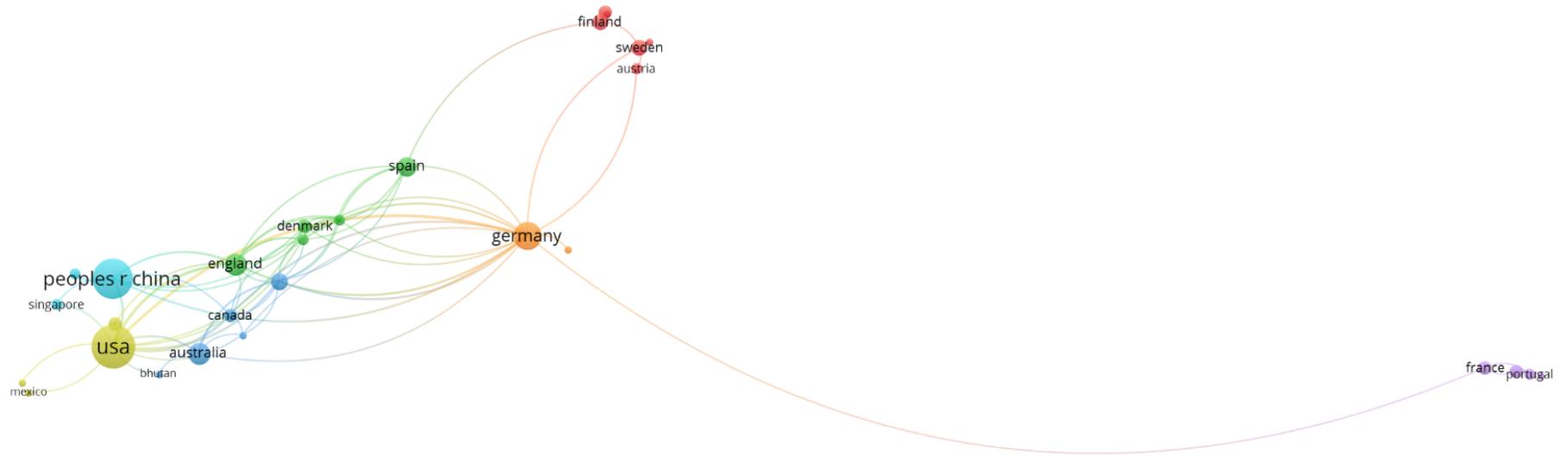


Figure 4: Map of clusters of co-author countries. Source: Own elaboration.

The other eight individual clusters (South Africa, Brazil, Slovakia, India, Malta, Morocco, Russia, and Togo) are not present because they contain only one country; they did not publish documents co-authored with other countries and probably are co-authored by institutions in the same country.

Among the documents recovered, there are 194 institutions responsible for the publications, with a concentration on universities and Research, Development, and Innovation (RD&I) institutes such as the Chinese Academy of Sciences (4 documents) in China; The Australian National University (3 documents), in Australia; Fudan University (3 documents), in China; and the University of California, Berkeley (3 papers) and University of Vermont (3 papers), both in the USA. Such information confirms the data presented in Figure 2. As Anjos (2020) pointed out, universities and RD&I institutions focus on developing knowledge for dissemination, linked or not to market or society demands.

There are banking institutions such as *Banque France* (1 document), Central Bank of Malta (1 document) and *Danmarks Nationalbank* (1 document), international organizations such as the World Bank (2 documents) and International Monetary Fund (1 document) and institution without for-profits such as Resources for the Future (2 documents). Studies published by institutions with no scientific or technological affiliation represent future commercial interests that will generate competitive advantage (Anjos 2020).

Figure 6 presents the cluster map of the co-author institutions, in which there is a polarization of Fudan University, The Australian National University, the University of California, Berkeley, the Norwegian University of Life Sciences, and Beijing Normal University. There is also a cluster with equivalent domains such as *Potsdam Institut für Klimafolgenforschung* (2 documents), Duke University, Duke Kunshan University, University of Washington, and University of Calgary (1 document each), interconnected with other clusters from Fudan University, University of California/Berkeley, and Norwegian University of Life Sciences, which are all partners in a single publication, of Yin et al. (2021).

The 106 documents retrieved in the search were published by 324 authors, with two publications for each of the fifteen authors listed in Table 6 and only one publication for the other 309 authors. Researchers from The Australian National University and the Norwegian University of Life Sciences, among the authors listed in Table 6, confirm the polarization of these two institutions exerted in the map of clusters of co-author institutions in Figure 6.

Table 6: Fifteen authors with the highest number of publications among the 106 documents retrieved

Authors	Institutions	Countries
Aizenman, Joshua	University of Southern California	USA
Boyd, James	Resources for the Future	USA
Chen, Jibo	Nanjing University of Information Science & Technology	China
Costanza, Robert	Australian National University	Australia
de Lange, Willem	Council for Scientific & Industrial Research (CSIR)	South Africa
Dong Xiao-lin	Chang'an University	China
Jinjarak, Yothin	University of London	UK
Muller, Nicholas Z	Carnegie Mellon University	USA
Nahman, Anton	Council for Scientific & Industrial Research (CSIR)	South Africa
Navrud, Stale	Norwegian University of Life Sciences	Norway
Song Cheng	Chang'an University	China
Wang, Guizhi	Nanjing University of Information Science & Technology	China
Wu Ying-chao	Chang'an University	China
Yang Jian-jun	Chang'an University	China
Yin, Hao	Tsinghua University	China

Source: Own elaboration.

The publications retrieved in the search were published in 74 journals and annals of scientific events. Table 7 presents the journals with more than one publication and their impact factors in 2020.

Table 7: Journals with more than one publication among the 106 documents retrieved

Records	Journal	ISSN	Impact factor in 2024
10	Ecological Economics	0921-8009	6.3
5	Environmental & Resource Economics	0924-6460	3.4
4	Review of Income and Wealth	0034-6586	1.8
3	International Journal of Environmental Research and Public Health	1660-4601	4.614
3	Proceedings of the National Academy of Sciences of the United States of America	0027-8424	9.1
2	Accounting Review	0001-4826	4.4
2	Ecological Indicators	1470-160X	7.4
2	Ecosystem Services	2212-0416	6.6
2	Environmental Science and Pollution Research	0944-1344	-
2	Journal of International Money and Finance	0261-5606	3.3
2	Sustainability	2071-1050	3.3
2	Waste Management	0956-053X	7.1

Source: Own elaboration.

The listed journals cover areas such as Economics, Environmental Sciences, Ecology and Finance, and Business, which are more prominent and compatible with the findings in Figure 2. There are also journals on Public, Environmental and Occupational Health topics, presented in Figure 2 in a dispersed and punctual manner in a few years. Figueiredo (2016) points out the interdisciplinarity and multidisciplinary 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.

This article is a theoretical essay that presents the state-of-the-art relationship between Environmental Economic Valuation and the System of National Accounts (SNA), unifying accounting, and economic elements to develop future indicators for Green Gross Domestic Product (Green GDP) calculation.

Holub, Tappeiner and Tappeiner (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. Other negative points were the necessity for correct pricing of all assets in monetary terms and the fictitious character of monetization of environmental assets that leads to misinterpretation. 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; Tappeiner; Tappeiner, 1999). 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).

Compared to Holub, Tappeiner and Tappeiner (1999) and Boyd (2007), Li and Fang (2014) and Yuan, Lo and Yang (2017) published their research results ten years later in other social, economic, and environmental world scenarios. Both papers pointed to another description of Green GDP that denotes its viability for application and the alignment with SEEA, with two challenges.

The first challenge refers to the contribution of ecosystem services to economic activities before, during, and after the verification to calculate the Green GDP using only one framework. An example is the migration of some animals through continents that provide different services in more than one ecosystem (Yuan; Lo; Yang, 2017; King et al., 2021). The second challenge is a different perception and the economic and legal aspects between each country to obtain the Green GDP, which leads to few scientific studies about this theme with the correlation of each SNA and the mechanisms to incorporate in the national welfare (Yuan; Lo; Yang, 2017).

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.

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, Tappeiner and Tappeiner (1999), Boyd (2007), Li and Fang (2014), and Yuan, Lo and Yang (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 stronger connection to each country's social, economic, and environmental situations.

5. Final considerations

The CBD is considered one of the most important international regulatory frameworks on the environment and the guideline for developing regulatory legislation on biodiversity in some countries. The integration of ecosystems in the planned actions of the public and private sectors also meets the goals established in the Sustainable Development Goals (SDGs) by contemplating natural capital in the environmental, economic, and social fields.

Natural capital needs to be quantified and evidenced in the System of Environmental-Economic Accounts, as opposed to the traditional System of National Accounts. After analysis and discussions, it became evident that the information brought by the Gross Domestic Product reflects only the information of the economic system, without considering the environmental system in which we are inserted. Thus, it is necessary to develop environmental satellite accounts to be included in the Green Gross Domestic Product.

For the quantification and disclosure of the national ecological heritage, that nation's natural resources must be valued to be included in the calculation of the Green GDP. Furthermore, the economic valuation of the environment will contribute to the measurement of the depletion (depreciation) of environmental resources, which must be considered in the calculation of the Green GDP through the reduction of the national ecological heritage and support fiscal sustainability practices and climate disclosure reports by developing indicators, including updating standards like International Sustainability Standards Board (ISSB).

Through the bibliometric analysis of the state-of-the-art relationship between the Economic Valuation of the Environment and the System of National Accounts, it was possible to systematize the studies carried out between 1945 and 2022 on economic valuation and gross domestic product, including the environmental component, which recovered 106 articles and four articles, respectively.

It found the existence of publications on the subject on all continents, especially Europe, Asia, and North America, and many African documents. Among the institutions, there is a predominance of universities and R&D organizations, and banks, which are interested in the subject aiming at competitiveness in its market. It was also noticed that interactions between countries and publishing institutions were found, which shows the existence of partnerships for the generation and sharing of knowledge.

The first publications of the temporal scope, in 1993 and 1997, coincided with the formal beginning of research in the monetization of environmental services. Another important finding is the publication of documents on Environmental Sciences, Environmental Studies, and Ecology as of 1997 and on Agricultural Policy and Economics as of 2014, which shows the evolution of valuation and association with GDP with a focus on the environment. and later in the economic exploitation of biodiversity targeting issues such as renewable energy and food security. This scientific evolution also occurred concomitant with international initiatives to control climate change and greenhouse gas emissions, 2030 Agenda for Sustainable Development, Rio+20, Paris Agreement, and Kyoto Protocol, associated to Artificial Intelligence tools to integrate SEEA data with national information for higher quality data organization and future and faster disclosure and information access. As limitations were perceived in this study, gaps were identified regarding the lack of consensus on the limits that a model should apply, with the purpose of quantification and disclosure of natural capital, requiring the development of a conceptual framework for the consolidation of this understanding. In the same sense, the lack of validated methodologies for the inclusion of natural capital in the calculation of national wealth, which can be systematized in a future study by incorporating grey literature to expand the corpus and to reduce bias from each country (lack of access to data, institutional capacity, and funding).

Considering the limitations above, developing a proposal for calculating any country's Green Gross Domestic Product is still at an early stage. However, the signatory countries' ratification of the Nagoya Protocol can stimulate the application of economic valuation methods to strengthen the national sovereignty of ecosystems and biodiversity and guarantee the adequate inclusion of environmental assets in the calculation of national wealth. Furthermore, an adequate and validated conceptual framework can be an analytical tool to resolve externalities for developing public policies to support decision-making for the conservation and preservation of national biodiversity.

6. References

- ANDRADE, Kátia Maria Paula de. **Bioeconomia: um estudo das vocações, fragilidades e possibilidades para o desenvolvimento no estado do Amazonas**. 2017. Tese (Doutorado em Ciência Ambiental) - Universidade Federal do Amazonas, Manaus, 2017. Available at: <https://tede.ufam.edu.br/handle/tede/5985>. Accessed in: 3 jun, 2021.
- ANJOS, Sérgio Saraiva Nazareno dos. Análise prospectiva da produção científica de valoração econômica de biotecnologia entre os anos de 1945 e 2019. **Revista de Economia da UEG**, Itumbiara, v. 16, p. 71-86, 2020. DOI: 10.31668/reueg.v16i2.10411. Available at: <https://www.revista.ueg.br/index.php/economia/article/view/10411>. Accessed in: 30 dez. 2022.
- ANJOS, Sérgio Saraiva Nazareno dos; ISSIFOU, Mourtala. Métodos de valoração econômica de ativos culturais e ambientais. In: FREIRE, F. de S. et al. (Org.). **Contabilidade Socioambiental**. 1. ed. Curitiba: Juruá, 2022. p. 135-154.
- BARBIER, Edward. B. The concept of natural capital. **Oxford Review of Economic Policy**, Oxford, v. 35, n. 1, p. 14-36, 2019. DOI: 10.1093/oxrep/gry028. Available at: <https://academic.oup.com/oxrep/article/35/1/14/5267896>. Accessed in: 30 out, 2025.
- BARCELLOS, Frederico Cavadas; CARVALHO, Paulo Gonzaga Mibielli Sustainability and Monetary Valuation of Natural Assets in the Context of Environmental Accounting. In: SEMINÁRIO DE METODOLOGIA DO IBGE, 7., 2018, Rio de Janeiro. **Anais [...]**. Rio de Janeiro: IBGE, 2018. Available at: <https://eventos.ibge.gov.br/downloads/smi2018/resumos/apresentacoesorais/OR1%20-%20Frederico%20Cavadas%20Barcellos%20e%20Paulo%20Gonzaga%20M.%20de%20Carvalho.pdf>. Accessed in: 8 mai 2022.
- BAVEYE, Philippe C.; BAVEYE, Jacques; GOWDY, John. Monetary valuation of ecosystem services: It matters to get the timeline right. **Ecological Economics**, Amsterdam, v. 95, p. 231-235, 2013. DOI: 10.1016/j.ecolecon.2013.09.009. Available at: <https://www.sciencedirect.com/science/article/pii/S0921800913002954>. Accessed in: 30 out, 2025.
- BOYD, J. Nonmarket benefits of nature: What should be counted in green GDP? **Ecological Economics**, Amsterdam, v. 61, n. 4, p. 716-723, 2007. DOI: 10.1016/j.ecolecon.2006.06.016. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0921800906004642>. Accessed in: 8 mai 2022.
- BRAZIL. **Decreto nº 6.040, de 7 de fevereiro de 2007**. Institui a Política Nacional de Desenvolvimento Sustentável dos Povos e Comunidades Tradicionais. Diário Oficial da União: seção 1, Brasília, DF, ano 144, n. 28, p. 2, 8 fev. 2007. Available at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/decreto/d6040.htm. Accessed in: 23 abr. 2022.
- CHANDRA, Alvin; IDRISOVA, Anastasiya. Convention on Biological Diversity: a review of national challenges and opportunities for implementation. **Biodiversity and Conservation**, Dordrecht, v. 20, n. 14, p. 3295-3316, 2011. DOI: 10.1007/s10531-011-0141-x. Available at: <https://link.springer.com/article/10.1007/s10531-011-0141-x>. Accessed in: 8 mai 2022.
- CLARIVATE ANALYTICS. **Web of Science core collection help: Research Areas (Categories/Classification)**. 2025. Available at: https://support.clarivate.com/ScientificandAcademicResearch/s/article/Web-of-Science-Core-Collection-Web-of-Science-Categories?language=en_US. Accessed in: 2 nov. 2025.
- COMTE, Adrien; SYLVIE CAMPAGNE, C.; LANGE, Sabine; BRUZÓN, Adrián García; HEIN, Lars; SANTOS-MARTÍN, Fernando; LEVREL, Harold. Ecosystem accounting: Past scientific developments and future challenges. **Ecosystem Services**, Amsterdam, v. 58, e101486, 2022. DOI: 10.1016/j.ecoser.2022.101486. Available at:

<https://www.sciencedirect.com/science/article/abs/pii/S2212041622000821?via%3Dihub>. Accessed in: 2 nov. 2025.

CRUZ-GARCIA, Gisella S.; SACHET, Erwan; BLUNDO-CANTO, Genowefa; VANEGAS, Martha; QUINTERO, Marcela. To what extent have the links between ecosystem services and human well-being been researched in Africa, Asia, and Latin America? **Ecosystem Services**, Amsterdam, v. 25, p. 201-212, 2017. DOI: 10.1016/j.ecoser.2017.04.005. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S2212041616305137>. Accessed in: 2 nov. 2025.

CUI, Can; ZHANG, Yu. Integration of Shared Micromobility into Public Transit: A Systematic Literature Review with Grey Literature. **Sustainability**, Basel, v. 16, n. 9, e3557, 2024. DOI: 10.3390/su16093557. Available at: <https://www.mdpi.com/2071-1050/16/9/3557>. Accessed in: 2 nov. 2025.

DASGUPTA, Partha. **The Economics of Biodiversity: The Dasgupta Review**. London: HM Treasury, 2021. Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962785/The Economics of Biodiversity The Dasgupta Review Full Report.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962785/The_Economics_of_Biodiversity_The_Dasgupta_Review_Full_Report.pdf). Accessed in: 4 mar. 2022.

EIGENRAAM, Mark; OBST, Carl. Extending the System of National Accounts (SNA) production boundary to classify and account for ecosystem services. **Ecosystem Health and Sustainability**, Abingdon, v. 4, n. 9, p. 247-260, 2018. DOI: 10.1080/20964129.2018.1524718. Available at: <https://www.tandfonline.com/doi/full/10.1080/20964129.2018.1524718>. Accessed in: 2 nov. 2025.

FEIJÓ, Carmen Aparecida; RAMOS, Roberto Luís Olinto. **Contabilidade social: a nova referência das contas nacionais do Brasil**. 5. ed. Rio de Janeiro: Elsevier, 2017.

FIGUEIREDO, Carla Taciane. **Ciências ambientais no Brasil: história, métodos e processos**. 2016. Tese (Doutorado em Ciências da Saúde) - Universidade Federal de Sergipe, São Cristóvão, 2016. Available at: <https://ri.ufs.br/jspui/handle/riufs/4204>. Accessed in: 8 maio 2022.

GOIS, Alessandro Barreto; ISSIFOU, Mourtala; ANJOS, Sérgio Saraiva Nazareno dos. Responsabilidade socioambiental e desenvolvimento sustentável. In: FREIRE, F. de S. et al. (Org.). **Contabilidade Socioambiental**. 1. ed. Curitiba: Juruá, 2022. p. 15-44.

GOIS, Alessandro Barreto; NOGUEIRA, Jorge Madeira. A contribuição da valoração econômica ambiental para o cálculo do PIV brasileiro. In: ENCONTRO INTERNACIONAL SOBRE GESTÃO EMPRESARIAL E MEIO AMBIENTE (ENGEMA), 22., 2020, São Paulo. **Anais [...]**. São Paulo: USP, 2020. Available at: http://engemausp.submissao.com.br/22/anais/resumo.php?cod_trabalho=619. Accessed in: 24 abr. 2022.

GOIS, Alessandro Barreto; NOGUEIRA, Jorge Madeira. Long and Challenging Roads to Green GDP: International Initiatives. **Revista De Gestão Social e Ambiental - RGSA**, São Paulo, v. 19, n. 2, e011185, 2025. DOI: 10.24857/rgsa.v19n2-023. Available at: <https://rgsa.openaccesspublications.org/rgsa/article/view/11185>. Accessed in: 2 nov. 2025.

HAHN, Thomas; MCDERMOTT, Constance; ITUARTE-LIMA, Claudia; SCHULTZ, Maria; GREEN, Tom; TUVENDAL, Magnus. Purposes and degrees of commodification: Economic instruments for biodiversity and ecosystem services need not rely on markets or monetary valuation. **Ecosystem Services**, Amsterdam, v. 16, p. 74-82, 2015. DOI: 10.1016/j.ecoser.2015.10.012. Available at: <https://www.sciencedirect.com/science/article/pii/S2212041615300395>. Accessed in: 2 nov. 2025.

HELM, Dieter. Natural capital: assets, systems, and policies. **Oxford Review of Economic Policy**, Oxford, v. 35, n. 1, p. 1-13, 2019. DOI: 10.1093/oxrep/gry027. Available at: <https://academic.oup.com/oxrep/article-abstract/35/1/1/5268055>. Accessed in: 2 nov. 2025.

HOFF, Jens V.; RASMUSSEN, Martin M. B.; SØRENSEN, Peter Birch. Barriers, and opportunities in developing and implementing a Green GDP. **Ecological Economics**, Amsterdam, v. 181, e106905, 2021. DOI: 10.1016/j.ecolecon.2020.106905. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0921800920321960>. Accessed in: 2 nov. 2025.

HOLUB, Hans Werner; TAPPEINER, Gottfried; TAPPEINER, Ulrike. Some remarks on the 'System of Integrated Environmental and Economic Accounting' of the United Nations. **Ecological Economics**, Amsterdam, v. 29, n. 2, p. 329-336, 1999. DOI: 10.1016/S0921-8009(98)00087-1. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0921800998000871>. Accessed in: 2 nov. 2025.

IVANOV, Youri; RJABUSHKIN, Boris; HOMENKO, Tatjana. Introduction of the SNA into the official statistics of the Commonwealth of Independent States. **The Review of Income and Wealth**, Hoboken, v. 39, n. 3, p. 279-294, 1993. DOI: 10.1111/j.1475-4991.1993.tb00460.x. Available at: <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1475-4991.1993.tb00460.x>. Accessed in: 2 nov. 2025.

JOLY, Carlos A.; HADDAD, Célio Fernando Baptista; VERDADE, Luciano Martins; OLIVEIRA, Mariana C.; BOLZANI, Vanderlan da Silva; BERLINCK, Roberto Gomes de Souza. Diagnóstico da pesquisa em biodiversidade no Brasil. **USP Magazine**, São Paulo, n. 89, p. 114-133, 2011. DOI: 10.11606/issn.2316-9036.v0i89p114-133. Available at: <https://repositorio.usp.br/item/002197205>. Accessed in: 2 nov. 2025.

KING, Steven; VARDON, Michael; GRANTHAM, Hedley S.; EIGENRAAM, Mark; FERRIER, S.; JUHN, Daniel; LARSEN, Trond; BROWN, Claire; TURNER, Kerry. Linking biodiversity into national economic accounting. **Environmental Science & Policy**, Amsterdam, v. 116, p. 20-29, 2021. DOI: 10.1016/j.envsci.2020.10.020. Available at: <https://research-portal.uea.ac.uk/en/publications/linking-biodiversity-into-national-economic-accounting/>. Accessed in: 2 nov. 2025.

LI, Guangdong.; FANG, Chuanglin. Global mapping and estimating ecosystem services values and gross domestic product: A spatially explicit integration of national 'green GDP' accounting. **Ecological Indicators**, Amsterdam, v. 46, p. 293-314, 2014. DOI: 10.1016/j.ecolind.2014.05.020. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S1470160X14002222>. Accessed in: 2 nov. 2025.

MACE, Georgina. M. The ecology of natural capital accounting. **Oxford Review of Economic Policy**, Oxford, v. 35, n. 1, p. 54-67, 2019. DOI: 10.1093/oxrep/gry023. Available at: <https://academic.oup.com/oxrep/article-abstract/35/1/54/5267893>. Accessed in: 2 nov. 2025.

MARTINS, Nuno Ornelas. The economics of biodiversity: Accounting for human impact in the biosphere. **Ecological Economics**, Amsterdam, v. 189, e107150, 2021. DOI: 10.1016/j.ecolecon.2021.107150. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0921800921002081>. Accessed in: 2 nov. 2025.

MILLENNIUM ECOSYSTEM ASSESSMENT (MEA). **Ecosystems and Human Well-Being: Synthesis**. Washington, DC: Island Press, 2005.

MILES, Ian; SARITAS, Ozcan; SOKOLOV, Alexander. **Foresight for Science, Technology and Innovation**. Cham: Springer International Publishing AG Switzerland, 2016.

MUELLER, Charles Curt. **Os economistas e as relações entre o sistema econômico e o meio ambiente**. 1. ed. Brasília: Editora Universidade de Brasília, 2012.

NOGUEIRA, Jorge Madeira; MEDEIROS, Marcelino Antonio Asano de; ARRUDA, Flavia Silva Tavares de. Economic valuation of the environment: science or empiricism? **Cadernos de Ciência**

- & Tecnologia**, Brasília, v. 17, n. 3, p. 81-115, 2000. DOI: 10.35977/0104-1096.cct2000.v17.8870. Available at: <https://seer.sct.embrapa.br/index.php/cct/article/view/8870>. Accessed in: 30 dez. 2022.
- OBST, Carl; HEIN, Lars; EDENS, Bram. National Accounting and the Valuation of Ecosystem Assets and Their Services. **Environmental and Resource Economics**, Dordrecht, v. 64, n. 1, p. 1-23, 2016. DOI: 10.1007/s10640-015-9921-1. Available at: <https://link.springer.com/article/10.1007/s10640-015-9921-1>. Accessed in: 2 nov. 2025.
- PELLETIER, Marie-Chantale; HEAGNEY, Elizabeth; KOVAČ, Mladen. Valuing recreational services: A review of methods with application to New South Wales National Parks. **Ecosystem Services**, Amsterdam, v. 50, e101315, 2021. DOI: 10.1016/j.ecoser.2021.101315. Available at: <https://www.sciencedirect.com/science/article/pii/S2212041621000735>. Accessed in: 2 nov. 2025.
- SABBAHI, Rachid. Economic value of insect pollination of major crops in Morocco. **International Journal of Tropical Insect Science**, Cambridge, v. 42, p. 1275–1284, 2022. DOI: 10.1007/s42690-021-00645-x. Available at: https://www.researchgate.net/publication/354597340_Economic_value_of_insect_pollination_of_major_crops_in_Morocco. Accessed in: 2 nov. 2025.
- SANTOYO, Alain Hernández; NEVES, Otávio Junio Faria; MENDONÇA, Italo do Nascimento; DIAS, Marcelo Fernandes Pacheco; MENEZES, Gabrielito Rauter. Economic Growth and Environmental Sustainability in Latin American Countries: A Green GDP Approach. **Sociedade & Natureza**, Uberlândia, v. 37, e75607, 2025. DOI: 10.14393/SN-v37-2025-75607. Available at: <https://seer.ufu.br/index.php/sociedadennatureza/article/view/75607>. Accessed in: 2 nov. 2025.
- SILVA, Martim Francisco de Oliveira e; PEREIRA, Felipe dos Santos; MARTINS, José Vitor Bomtempo. A bioeconomia brasileira em números. **BNDES Setorial**, Rio de Janeiro, n. 47, p. 277-331, 2018. Available at: <https://web.bndes.gov.br/bib/jspui/handle/1408/15383>. Accessed in: 10 mar. 2022.
- SMESAERT, Jacob; MISSEMER, Antoine; LEVREL, Harold. The commodification of nature, a review in social sciences. **Ecological Economics**, Amsterdam, v. 172, e106624, 2020. DOI: 10.1016/j.ecolecon.2020.106624. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0921800919316337>. Accessed in: 2 nov. 2025.
- STIGLITZ, Joseph. E.; SEN, Amartya; FITOUSSI, Jean-Paul. **Report by the Commission on the Measurement of Economic Performance and Social Progress**. Paris: Commission on the measurement of economic performance and social progress, 2009. Available at: https://www.cps.fgv.br/ibrecps/nw/rapport_anglais_1-18.pdf. Accessed in: 21 fev. 2021.
- THORSTENSEN, Vera Helena; MOTA, Catherine Rebouças. **Os indicadores da OCDE e a regulação da diversidade biológica no Brasil**. São Paulo: Fundação Getúlio Vargas, Escola de Economia, 2021. (TD 547 CCGI 33). Available at: <https://hdl.handle.net/10438/30952>. Accessed in: 21 abr. 2022.
- UNITED NATIONS (UN). **Convention on Biological Diversity**. Rio de Janeiro: UN, 1992. Available at: https://treaties.un.org/doc/Treaties/1992/06/19920605%2008-44%20PM/Ch_XXVII_08p.pdf. Accessed in: 21 abr. 2022.
- UNITED NATIONS (UN). System of Environmental Economic Accounting. **Findings from the 2023 Global Assessment of Environmental-Economic Accounting**. 2025. Available at: <https://seea.un.org/news/findings-2023-global-assessment-environmental-economic-accounting>. Accessed in: 27 oct. 2025.
- UNITED NATIONS (UN). World Commission on Environment and Development (WCED). **Report of the World Commission on Environment and Development**. New York: UN, 1987. Available at: https://digitallibrary.un.org/record/139811/files/A_42_427-EN.pdf. Accessed in: 8 mai 2022.

- VAN ECK, Nees Jan; WALTMAN, Ludo. Visualizing Bibliometric Networks. In: DING, Ying; ROUSSEAU, Ronald; WOLFRAM, Dietmar. (ed.). **Measuring Scholarly Impact**. Cham: Springer, 2014. p. 285-320. DOI: 10.1007/978-3-319-10377-8_13. Available at: https://link.springer.com/chapter/10.1007/978-3-319-10377-8_13. Accessed in: 2 nov. 2025.
- YIN, Hao; BRAUER, Michael; ZHANG, Junfeng Jim; CAI, Wenjia; NAVRUD, Ståle; BURNETT, Richard; HOWARD, Courtney; DENG, Zhu; KAMMEN, Daniel M; SCHELLNHUBER, Hans Joachim; CHEN, Kai; KAN, Haidong; CHEN, Zhan-Ming; CHEN, Bin; ZHANG, Ning; MI, Zhifu; COFFMAN, D'Maris; COHEN, Aaron J; GUAN, Dabo; ZHANG, Qiang; GONG, Peng; LIU, Zhu. Population aging and deaths attributable to environmental PM2.5 pollution: a global analysis of economic cost. **Lancet Planetary Health**, London, v. 5, n. 6, p. E356-E367, 2021. DOI: 10.1016/S2542-5196(21)00131-5. Available at: <https://pubmed.ncbi.nlm.nih.gov/34119010/>. Accessed in: 2 nov. 2025.
- YOUNG, Carlos Eduardo Frickmann; PIMENTEIRA, Cicero Augusto Prudencio; ALMEIDA, Valéria. P. Contabilidade Ambiental Nacional: fundamentos teóricos. In: MAY, Peter. (Org.). **Economia do Meio Ambiente: teoria e prática**. 3. ed. Rio de Janeiro: Elsevier, 2018. p. 179-202.
- YUAN, Mei-Hua; LO, Shang-Lien; YANG, Chih-Kai. Integrating ecosystem services in terrestrial conservation planning. **Environmental Science and Pollution Research**, Berlin, v. 24, n. 13, p. 12144–12154, 2017. DOI: 10.1007/s11356-017-8795-x. Available at: <https://pubmed.ncbi.nlm.nih.gov/28349311/>. Accessed in: 2 nov. 2025.