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# Distinguishing Ecological Economics from Environmental Economics, Green Economy, Circular Economy, and Bioeconomy in the 21st Century

# Distinguiendo la Economía Ecológica de la Economía Ambiental, la Economía Verde, la Economía Circular y la Bioeconomía en el siglo XXI

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**Keywords:** bibliographic databases, meta-analysis, paradigms, environment, economy, ecological economics.

**Palabras Clave:** bases de datos bibliográficas, meta-análisis, paradigmas, medio ambiente, economía, economía ecológica.

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## ABSTRACT

**Context.** In the 21st century, several economic-environmental approaches —such as ecological economics, environmental economics, green economy, circular economy, and bioeconomy— have emerged to address the increasing complexity of sustainability challenges. These frameworks stem from different historical, regional, and disciplinary contexts and reflect diverse interpretations of the relationship between the economy and the environment.

**Problem**. Although they share a common concern for sustainability, these approaches often overlap in terminology and scope, generating conceptual ambiguity and reducing their analytical clarity and policy relevance. The central question is: what distinguishes ecological economics from other paradigms in the 21st century?

**Purpose**. The purpose of this study is to differentiate ecological economics from other contemporary approaches that analyze the relationship between economy and environment. It reviews 21st-century scientific literature to establish conceptual similarities and differences, focusing on theoretical foundations and keywords.

**Methodology.** A meta-analysis was conducted on peer-reviewed articles indexed in Scopus between 2000 and 2020. Author-defined keywords were analyzed in terms of frequency, co-occurrence, and exclusivity to identify conceptual patterns among the five approaches.

**Theoretical and Practical Findings.** *Ecological economics* is distinguished by its emphasis on biophysical limits, social metabolism, political ecology, and distributional conflicts. Theoretically (*Scientia*), it helps delimit paradigmatic boundaries; practically (*Praxis*), it guides public policies and academic programs with a critical perspective on sustainability and justice. It contributes to **SDG 8** by encouraging structural economic transformation, and to **SDG 13** through its focus on climate action.

**Originality.** The study applies a multidisciplinary approach that contrasts market-based models with an ecological paradigm centered on justice. It proposes *"ecologizing the economy"* rather than *"economizing ecology."*

**Conclusions and Limitations.** *Ecological economics* emerges as a distinct paradigm. Its main limitation is the exclusive use of English sources. Future research should adopt multilingual and participatory approaches. It also supports **SDG 8** and **SDG 13** through inclusive and climate-focused strategies.




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## RESUMEN

**Contexto.** En el siglo XXI han surgido diversos enfoques económico-ambientales —como la economía ecológica, la economía ambiental, la economía verde, la economía circular y la bioeconomía— para enfrentar la complejidad creciente de los desafíos de la sostenibilidad. Estos marcos provienen de distintos contextos históricos, regionales y disciplinares, y reflejan diversas interpretaciones sobre la relación entre economía y medio ambiente.

**Problema.** Aunque comparten una preocupación por la sostenibilidad, estos enfoques suelen solaparse en su terminología y alcance, lo que genera ambigüedad conceptual y reduce su claridad analítica y utilidad política. La pregunta central es: ¿qué distingue a la economía ecológica de los demás paradigmas en el siglo XXI?

**Propósito.** El propósito de este estudio es diferenciar a la economía ecológica de otros enfoques contemporáneos que analizan la relación entre economía y ambiente. Se revisa literatura científica del siglo XXI para establecer similitudes y diferencias conceptuales, enfocándose en fundamentos teóricos y palabras clave.

**Metodología.** Se aplicó un meta-análisis sobre artículos arbitrados indexados en Scopus entre 2000 y 2020. Se analizaron palabras clave definidas por los autores según frecuencia, coocurrencia y exclusividad, con el fin de identificar patrones conceptuales entre los cinco enfoques.

**Hallazgos teóricos y prácticos.** La economía ecológica se distingue por su énfasis en los límites biofísicos, el metabolismo social, la ecología política y los conflictos distributivos. Teóricamente (Scientia), delimita los marcos paradigmáticos; en la práctica (Praxis), orienta políticas públicas y programas académicos con perspectiva crítica sobre sostenibilidad y justicia. Contribuye al **ODS 8** por la transformación económica estructural, y al **ODS 13** mediante su enfoque en la acción climática.

**Originalidad.** El estudio aplica un enfoque multidisciplinario que contrasta modelos de mercado con un paradigma ecológico centrado en la justicia. Propone *"ecologizar la economía"* en vez de *"economizar la ecología"*.

**Conclusiones y limitaciones.** La economía ecológica emerge como un paradigma distinto. Su principal limitación es el uso exclusivo de fuentes en inglés. Investigaciones futuras deberían adoptar enfoques multilingües y participativos. También contribuye al **ODS 8** y al **ODS 13** mediante estrategias inclusivas y centradas en el clima.




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## 1. INTRODUCTION

In a given geographical area, the social and economic forms of organization establish characteristics that are specific to the transformation process of the natural environment. This depends, among other factors, on the possessions and demands for *"natural resources"* and the level and type of technology available. In any case, a systemic structure of the transformation process is shaped, which brings about socio-environmental issues related to the degradation of natural resources and the depletion of available net energy. As a result, inequities are reinforced and have uneven impacts on social classes and layers. These issues correspond to the realm of Political Ecology, in direct connection with Ecological Economics.

From a systemic perspective, the abovementioned can be explained by the simple reason that socioeconomic structures are inserted into a larger and more complex system that is given naturally, namely, the biosphere (Daly & Farley, 2004). In fact, not only can techno-structures exist, but also the whole economic dynamism depends on the flows of matter and energy coming from the natural system.

Mainstream economics consolidated throughout time with a progressive but marked disengagement from those natural bases. As it is also a social science, however, it has sought to address socio-environmental issues. Thus, it has expanded its scope but maintained its own categories of analysis (Ramos-Gorostiza, 2005). This is how Environmental Economics stands as a branch of conventional or hegemonic—mainstream— economics.

Under the same multiple assumptions of marginal analysis, Environmental Economics has developed a range of tools to address environmental challenges, including valuation methods and corrective taxation—such as environmental or health taxes (e.g., tobacco taxes) (Atondo-García, et al., 2025). Market logic, thus, has been extended to include proposals for nature monetization or privatization attempts.

As opposed to the sole —chrematistic— analysis criterion of Environmental Economics, there is a more critical, integrative, co-evolutionary, and multidisciplinary approach, Ecological Economics, which focuses on the relationships between the economic (sub)system and the environmental system.



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This is an expanding field of study that emphasizes the integrity and sustainability of ecosystem functions and structures in the long-term but also pays attention to the social differences within national boundaries and among countries.

Nevertheless, the approaches that attempt to analyze jointly the economic and environmental factors do not seem to end there. Vis-à-vis the social demands on who is to be made responsible for the environmental crisis, Environmental Economics and mainstream economics have been able to offer a series of proposals aimed at internalizing the environmental issue. Thus, concepts such as corporate social responsibility or Sustainable Development Goals (**SDGs**) (United Nations, nd.) have arisen in recent years.

This article is going to delve into a series of alternative approaches that have emerged from Environmental Economics and that tend to consider the environment in the economic aspects, namely, Green Economy, Circular Economy, and Bioeconomy.

## 2. CONTEXT

Current concerns about climate change, biodiversity loss, resource depletion, and social inequality have spurred frameworks that reconceptualize the economy, society, and environment. Ecological Economics, Environmental Economics, the Green Economy, the Circular Economy, and the Bioeconomy are prominent among these. A surge in international reports, institutional agendas, and academic initiatives highlights their relevance.

### 2.1.Ecological Economics

Ecological Economics s an interdisciplinary field that emphasizes the embeddedness of the economy within the biosphere, thereby acknowledging the biophysical limits to economic growth (Costanza et al., 2004). It prioritizes ecosystem services, natural capital preservation, and long-term sustainability over neoclassical notions of efficiency. The field critiques **GDP** growth as a sole development goal and explores alternatives such as degrowth and steady-state economics. Leading institutions include the International Society for Ecological Economics (n.d.) and its regional branches.

Notably, the contributions of authors like Georgescu-Roegen (1971), Daly (1977), Costanza et al. (2004), and Boulding (1966) are foundational references in this field. In Latin America,



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ecological economics has gained traction in critiques of extractivism, territorial conflicts, and the valuation of indigenous knowledge systems. Scholars from Brazil, Argentina, and Colombia have contributed to post-extractivist approaches and debates around ecological debt. The journal Ecological Economics (Elsevier, n.d.) remains a key international outlet, while region-specific perspectives are also disseminated through Revista de Iberoamericana Economía Ecológica (n.d.).

### 2.2.Environmental Economics

Environmental Economics is grounded in neoclassical economics, focuses on the internalization of environmental externalities via market-based mechanisms such as taxes, subsidies, and cap-and-trade systems. Its tools have become essential to public policy in both developed and developing countries. Global institutions such as the World Bank (n.d.), the OECD (2022), and Resources for the Future (2023) advance this approach.

Key publications include the OECD Environmental Outlook to 2050 (OECD, 2012) and the World Bank's State and Trends of Carbon Pricing annual series (n.d.). In Latin America, environmental economics has supported mechanisms like payments for ecosystem services (PES) and carbon markets. Regional institutions such as ECLAC (n.d.) and Centro Latinoamericano para el Desarrollo Sustentable (LACEEP) contribute to applied research. However, critiques persist regarding the commodification of nature and the limitations of cost-benefit analyses in complex socio-ecological contexts.

### 2.3. Green Economy

The **Green Economy**, popularized by the United Nations Environment Programme (UNEP) (n.d.), proposes a model that seeks improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities. UNEP (2011) flagship report *"Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication"* remains a cornerstone document, highlighting priority sectors like renewable energy, sustainable agriculture, and public transport.

Globally, green economy strategies have influenced the Sustainable Development Goals (**SDGs**), particularly **SDG 8** (decent work and economic growth) and **SDG 12** (responsible consumption and production). In Latin America, UNEP (n.d.) and ECLAC (n.d.) have promoted



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national green economy plans, with countries like Uruguay and Costa Rica advancing policy roadmaps. The Green Economy Coalition (n.d.) curates case studies and tracks implementation worldwide.

### 2.4. Circular Economy

The **Circular Economy (CE)** proposes a systemic shift from linear *"take-make-dispose"* models to circular systems based on reuse, repair, remanufacturing, and recycling. The Ellen MacArthur Foundation (n.d.) has been central to conceptual development, particularly through reports like *"Completing the Picture: How the Circular Economy Tackles Climate Change"* and *"Cities and Circular Economy for Food"*.

The European Union has institutionalized the concept through its Circular Economy Action Plan (European Commission, 2020) and the European Circular Economy Stakeholder Platform (European Commission & European Economic and Social Committee, n.d.).

**In Latin America**, Circular Economy has gained momentum through public-private partnerships, urban innovation, and industrial symbiosis initiatives. Countries like Chile, Colombia, and Argentina have adopted Circular Economy strategies, often with support from the ECLAC. The ECLAC (2021) report "*Hacia una economía circular en América Latina y el Caribe"* offers a regional synthesis, while national strategies such as Colombia's Pacto por la Economía Circular and Argentina's Estrategia Nacional de Economía Circular serve as localized frameworks.

### 2.5. Bioeconomy

The **Bioeconomy** encompasses the sustainable production, use, and conservation of biological resources, integrating sectors such as agriculture, forestry, fisheries, bioenergy, and biotechnology. It promotes innovation in biobased products and services while aiming to reduce dependency on fossil resources. Global leaders include the European Commission (2018), the OECD (2022), and the FAO (n.d.).

The Global Bioeconomy Summit Reports (2015–2023) have emphasized the relevance of bioeconomy strategies for addressing global challenges (International Advisory Council on Global Bioeconomy [IACGB], 2023) and the Knowledge Policy Bioeconomy Platform (n.d.) are



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authoritative sources. Latin American bioeconomy development varies across subregions. Argentina, Brazil, and Uruguay have issued national bioeconomy strategies focused on biotechnology, biomass valorization, and regional development.

The FAO (2021) report *"Towards Sustainable Bioeconomy Guidelines: Shaping the Bioeconomy in Latin America and the Caribbean"* outlines policy frameworks tailored to the region's rich biodiversity and agricultural base. Key regional stakeholders include the Red Latinoamericana de Bioeconomía (REDBioLAC, n.d.), as well as national research institutions such as EMBRAPA in Brazil (EMBRAPA, 2023) and INTA in Argentina (INTA, 2022), all of which play a central role in advancing bioeconomy strategies across Latin America.

In sum, these five frameworks —ecological and environmental economics, green economy, circular economy, and bioeconomy— form a constellation of approaches that shape the discourse and practice of sustainability transitions at multiple scales. While global institutions have provided standard-setting guidance, Latin America offers unique applications grounded in biodiversity, social equity, and post-extractivist development paradigms. Understanding these interrelated frameworks is essential for crafting policies that are environmentally sound, socially inclusive, and economically viable.

To make visible how these approaches to economics and the environment have emerged in the 21st century, an online free tool is employed, **Google Ngram Viewer (2025)**.

It is an online search engine that employs *n-grams*, that is, subsequences of *n* words in a given text to carry out term searches in printed sources and in different languages. **Figure 1** shows how frequently the five approaches have appeared over time. This is a 5-year moving average.



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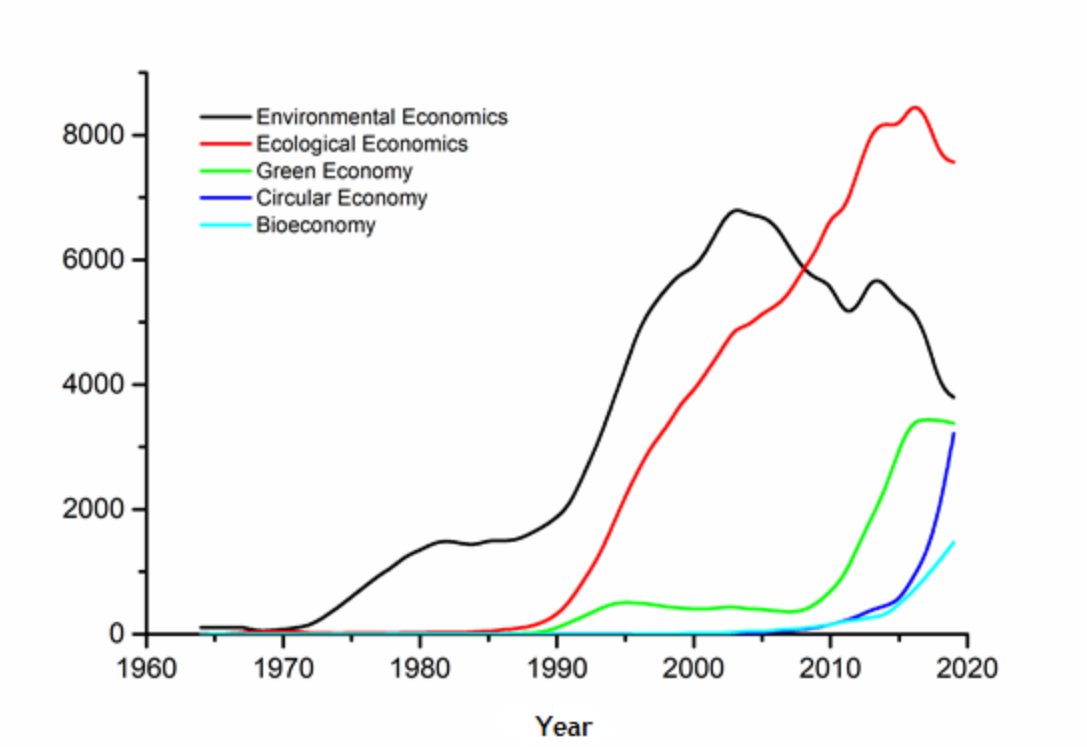
**Figure 1**. Time series of frequency of appearance for the five approaches




Source: Own elaboration using Google Spreadsheets based on data from Google Ngram (n.d.)

In the analysis period, the emergence of each approach is identified. Environmental Economics made its appearance in the 1970s and Ecological Economics in the 1990s. The other approaches have begun to appear much more recently, in particular Bioeconomy and Circular Economy. It is remarkable how many times more Environmental Economics appeared until the 2000s when two events took place:

**a.** Ecological Economics surpassed Environmental Economics, but in parallel

**b.** The other approaches started to develop.

Based on this preliminary analysis, there is greater dynamism and a concrete possibility of comparison among the five approaches starting in 2000. In fact, it was about ten years ago that the number of apparitions of some of these approaches began to be relevant (Green Economy) while for the others, it was only a few years ago (Bioeconomy and Circular Economy). In this way, two major reasons became sufficient to take the 21st century as the analysis period:



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1. To identify the distinctive features of these approaches today, or as close as today as possible (as opposed to a more historiographical or chronological theoretical-conceptual study), and
2. To incorporate in the analysis the newest and most dynamic approaches (Circular Economy, Bioeconomy, and Green Economy) that have appeared in recent years and that are of interest to compare.

Based on the appearance context of many *"labels"* or approaches to the relationship between economics and the environment, the main purpose of this article is to differentiate Ecological Economics from other approaches that intend to reflect such a relationship.

Thus, state-of-the-art research focused on marking the differences and similarities between Ecological Economics and other approaches—such as Environmental Economics— is assessed. To that end, the bibliography and bibliographic analyses of scientific journals are revised.

The methodology section justifies why it is important to take the 21st century as the analysis period. The following section delves into the founding and differential concepts and keywords of Ecological Economics by contrasting them with Environmental Economics, Green Economy, Circular Economy, and Bioeconomy. Then, from a selection of keywords and concepts, the differences between Ecological Economics and Environmental Economics are clearly established.

This section also aims at discussing the possibility of comparing the approaches to establish hierarchies and types of impacts economic activity has on the environment. Our initial hypothesis, however, is that Ecological Economics is the only approach that genuinely differentiates from the others. The last section resumes the main conclusions reached to in the article.

## 3. LITERATURE REVIEW

Here, we made a brief state of the art as a scientific production beyond slogans. In recent years, Ecological Economics has emerged as a distinct field, prompting efforts to differentiate it from Environmental Economics. Comparative studies highlight conceptual, methodological, and philosophical divergences. These distinctions reveal two separate paradigms in addressing economy-environment relations. In this sense, there have been rigorous and systemized endeavors involving theoretical-conceptual analysis, bibliography, influential authors, scope, impact ideas,



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differences, and similarities. In general, we can say that these differentiation attempts often come from authors who are pro Ecological Economics, or publish in journals devoted to Ecological Economics. There is a need to clearly distinguish Ecological Economics from Environmental Economics, which is closer to mainstream economics, and promote debate on it (Hoepner et al., 2012, Ma & Stern ,2006, and Van den Bergh, 2001). As a counterpart, there are very few attempts from Environmental Economics to differentiate itself from Ecological Economics.

One of the first comparative studies between Ecological Economics and Environmental Economics carried out in the 21st century is that of Van den Bergh (2001), which focuses on conceptual and thematic differences. Among his main conclusions, the author expresses that there is actually an overlapping between both approaches. Ecological Economics, however, is more pluralistic—it combines existing knowledge from other areas, hence its transdisciplinary character—and is also more creative and innovative than Environmental Economics at the conceptual level. In fact, almost all of the concepts used by Environmental Economics are taken directly from orthodox economics without further ado: externality; willingness to pay; opportunity cost, or are taken from it and are barely reprocessed: environmental goods, for example.

Ma and Stern (2006) analyze the citations from the articles of two specialized journals: the Journal of Environmental Economics and Management and Ecological Economics, standing for Environmental Economics and Ecological Economics, respectively. In the same line of analysis, Hoepner et al. (2012) also analyzed both approaches based on the number of influential articles, citations, authors and institutions. Díaz-Duarte et al. (2024) did it for the Circular Economy through a bibliometric review of scientific articles published in the Scopus database, analyzing the period from 2008 to 2023.

From Latin America, Cavalcanti (2010) arrives at an interesting conclusion: Ecological Economics does not constitute a branch of economics—neither of ecology—and the very name Ecological Economics can lead to confusion with Environmental Economics, since the former could well have been called eco-economics or economic ecology.



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Much more recently, Spash (2020) recognizes a series of internal fields within Ecological Economics, which explain not only the overlapping of topics with Environmental Economics but also their distinctive features. Among the authors who identify themselves with Ecological Economics, Spash (2020) distinguishes the following profiles:

**1.** Those who fully adhere to the dominant (neoclassical) economics, therefore, they are inseparable from Environmental Economics;

**2.** Authors who adopt tools and methods they consider to be useful, regardless of theoretical concerns or scientific rigor; and,

**3.** Authors he calls *"social ecological economists",* who seek to build a consistent theoretical approach that rejects faulty economic categories and theories.

The last position recognizes that Ecological Economics has a distinctive core and that it can be based on a critical and realistic philosophy of science. In addition, revisiting Dobson (1997), this last conceptualization within Ecological Economics is the closest to Ecologism and Political Ecology. Within this line, we could mention the so-called Radical Ecological Economics (Barkin et al. 2012).

Unlike Environmental Economics, which promotes a purely administrative approach to environmental issues, Ecological Economics is more disruptive inasmuch as it assumes that a sustainable existence means *"radical changes in our relationship with the non-human natural world, and in our mode of social and political life"* (Dobson, 1997, p. 22).

Finally, we must mention a current concern within Ecological Economics that we share. There has been a tendency to overuse tools for economic valuation, monetization, etc. Melgar-Melgar and Hall (2020) argue that the commitment of Ecological Economics to conceptual pluralism opened the doors to the same theories and methods that once served as its main criticism. Since then, Ecological Economics has become better known for its efforts to *"green"* the market economy through monetary valuation of nature (Melgar-Melgar & Hall, 2020). This has progressively taken it away from its original vision based on the biophysical understanding of the socioeconomic system and the criticism of the basic principles of mainstream economics.



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## 4. METHODOLOGY

The methodological criterion combines three aspects: using Scopus as a database of journals and scientific articles to be analyzed (**4.1**); selecting the keywords defined by the authors when submitting their manuscripts to journals (**4.2**); taking the 21st century as the analysis period **(4.3**).

### 4.1. Database used: Scopus

We employed Scopus (2025), one of the most used databases worldwide in terms of scientific publications. The database indexes scientific content from more than 25,000 peer-reviewed journals. In addition to the general searching work done with Scopus, a specific analysis of the articles published in Baumgärtner and Özkaynak (n.d.) the thematic journal in Scopus— was then carried out . Costanza et al. (2004) treat this journal as a representative sample of the papers produced within the field of Ecological Economics. It is quite an influential journal among the readers, with an impact factor of 4,482 at the moment of the web search. Furthermore, the vast majority of the results on *"ecological economics"* in Scopus correspond to that journal. Out of a total of 2,523 results including the term *"ecological economics"* whether in the title, abstract or keywords, 36% appear in the homonymous journal (the journal that follows in number of appearances is Acta Ecologica Sinica (n.d.), and represents only 3.36% of the results).

The use of a searching and indexing tool as Scopus —and in particular the analysis of that journal— allows us to establish a sort of global baseline since it is a mainstream informative forum for academia with international reach. Additionally, Ecological Economics has been employed as a thematic reference in the bibliometric articles of Ma and Stern (2006); Hoepner et al. (2012) and Zhu and Hua (2017), among others. However, they did not aim to identify distinctive features among the aforementioned economic-environmental approaches in the 21st century. The search in Scopus and in Ecological Economics is strongly limited to the English language, which is certainly a relevant fact.

### 4.2. Keywords as indicators

Another relevant aspect in our analysis is how data and metadata are defined, to be then contrasted in each approach. At first, we only compared keywords among scientific articles.



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Keywords help indexers and search engines to find relevant articles. All current scientific journals require authors to define a finite series —typically three to five— of keywords which can generally be compound words such as *"free will"*. There are some journals, however, that may request the use of specific encoders. This is not the case of any of the journals employed in this article.

In any case, keyword selection is up to the authors of the scientific articles and for this choice to be effective, it should be based on three simple principles:

**1.** Represent the content of the manuscript;

**2.** Be specific to the field or subfield of study and

**3.** Have an adequate balance between specificity and generality.

Considering such principles, it is evident that keywords are somehow a synthesis that authors employ to identify and associate themselves with a specific stance within their disciplinary field. In short, they are a self-definition or self-perception that is taken as a central element for analysis.

### 4.3. Analysis Period: the 21st century

The origins of what is now known as Environmental Economics can be traced back over a century, beginning with the publication of The Economics of Welfare by British economist Arthur Pigou (1920). In that seminal work—and later in A Study in Public Finance (Pigou, 1929)—Pigou elaborated on the concept of externalities, explored how taxation could enhance allocative efficiency, and addressed the empirical assessment of environmental damage. He thus laid the foundations for the modern field of Environmental Economics (Sandmo, 2015). Then, it consolidated as a discipline in the 1960s, when environmental issues intensified and, finally, in 1979, when the Association of Environmental and Resource Economists (AERE, n.d.) was formed.

As for Ecological Economics, it is more recent. It can be considered to have been instituted by the end of the 1980s, when the International Society for Ecological Economics (n.d) was founded in 1987 by Costanza and Herman Daly, who also founded the Ecological Economics journal (Elsevier, n.d.) in 1989.

Of course, the field of Ecological Economics recognizes previous contributions, both from economics and from other areas, such as ecology, physics, systems theory, to name a few (López-



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Calderón et al., 2013). Boulding (1966), Georgescu-Roegen (1971) and Daly (1977) made some of the most significant contributions to its institutionalization.

Similarly, we recognize a number of new and more recent approaches that relate economics to the environment. The early forerunners of the Green Economy are to be found, for instance, at the end of 1980, but there was a latency period during the 1990s and then it took off in the 21st century. In this sense, on the part of Bioeconomy and Circular Economy, it is necessary to mention that they have only appeared in the 21st century, although they have grown at a much faster pace.

Based on these differences and on their current relevance, as well as on the debates about the future, taking the 21st century as analysis period is quite reasonable.

## 5. RESULTS

This section presents the main findings derived from a comparative bibliometric analysis of the five approaches. The analysis is structured in four subsections, each contributing distinct evidence and insights about the scope, evolution, and distinguishing features of these frameworks in the scientific domain.

Section 5.1 opens with a quantitative exploration of the presence of each approach in the academic literature indexed in Scopus, revealing trends in their relative prominence and growth over the first two decades of the 21st century. It also assesses the degree of intersection between the topics by identifying shared and exclusive keywords.

Section 5.2 narrows the focus to Ecological Economics, using keyword frequency and distribution to better understand its position and central themes in comparison with the other four approaches.

Section 5.3 further investigates the semantic structure of each stream by grouping keywords into conceptual families, allowing for a visualization of their distinct academic identities.

Finally, Section 5.4 delves deeper into the specific divergences between Ecological Economics and Environmental Economics by applying a Boolean search strategy to targeted thematic terms, identifying points of convergence and differentiation in their scholarly treatment.



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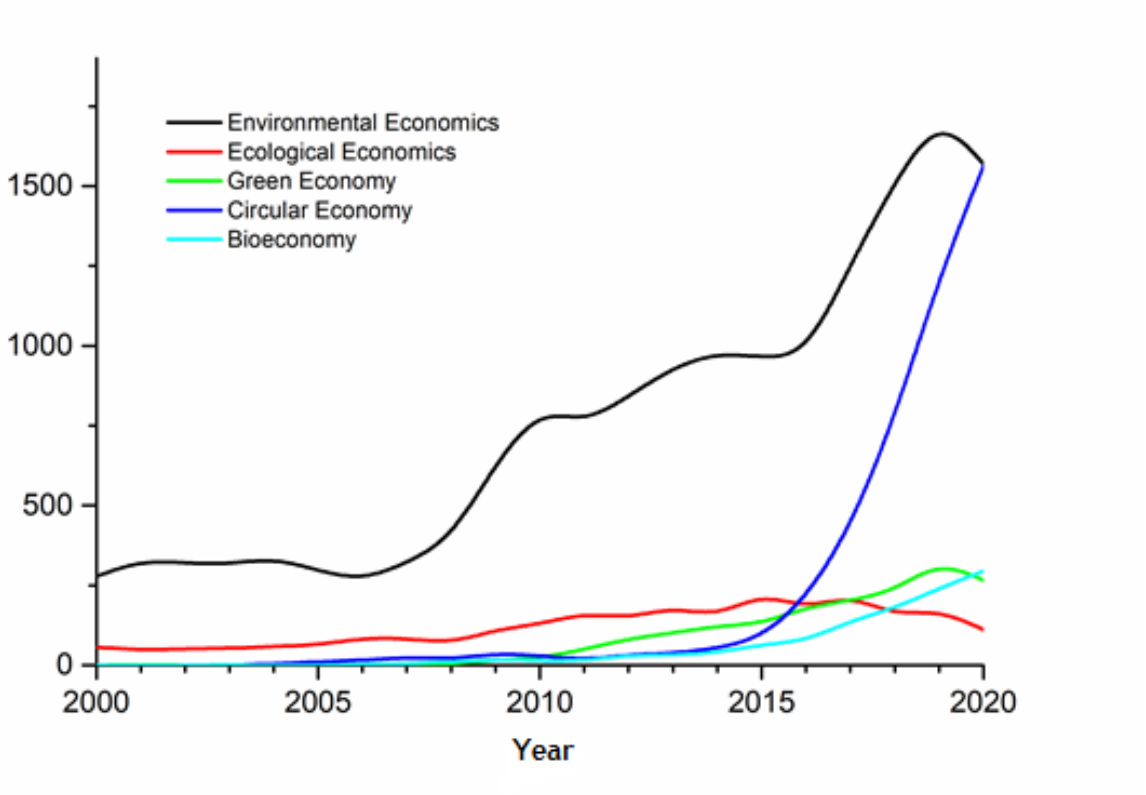
### 5.1.What does Scopus reveal?

Scopus was used as a complement to investigate these concepts or approaches in the scientific field, specifically in original articles published in the 21st century.

The **Figure 2** shows the absolute number of articles found in Scopus for each approach. The dynamics among them can be appreciated, especially in the last five years of the analysis period. This corresponds to the evidence also found through a bibliometric study about the expansion of the greenwashing phenomenon (Soriano-Sandoval & Alarcón-Sánchez, 2022).

**Figure 2: Number of annual publications for each approach**




Source: Own elaboration using Google Spreadsheets based on data from Scopus (n.d.)

On its part, **Figure 3** depicts the cumulative number of times that each approach appears.



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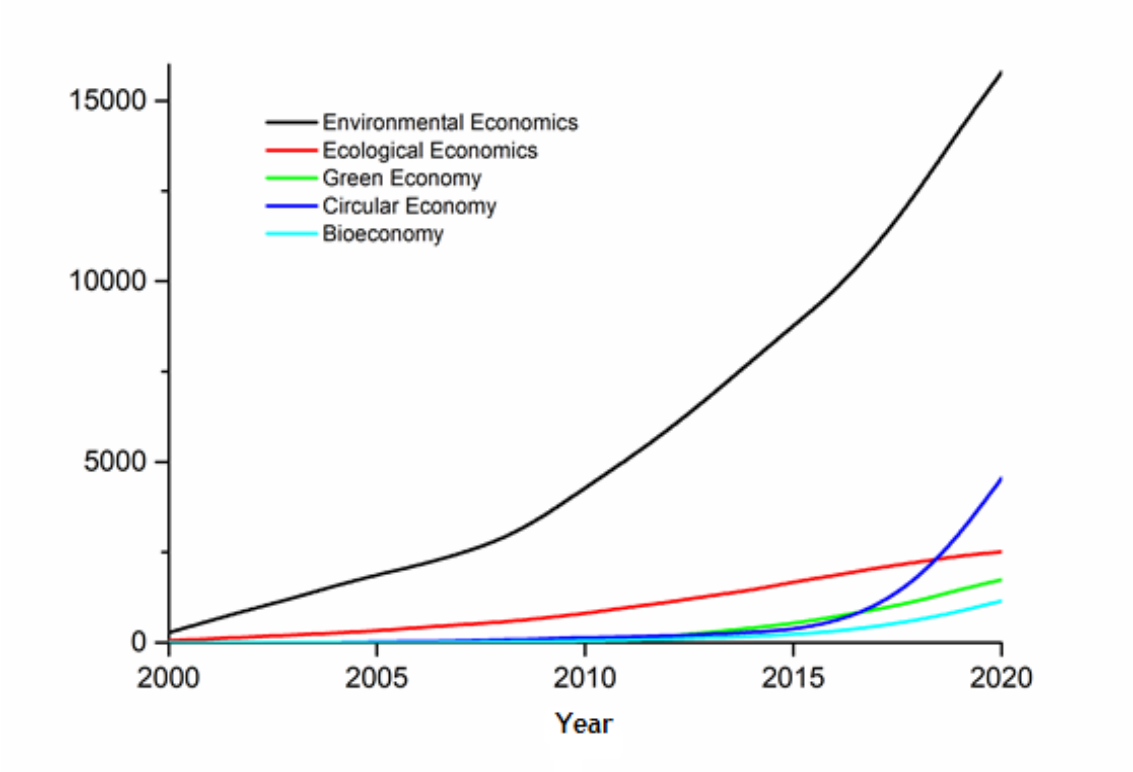
**Figure 3: Cumulative number of original scientific publications for each approach**




Source: Own elaboration using Google Spreadsheets based on data from Scopus (n.d.)

Notably, the number of articles on Environmental Economics significantly surpasses that of all other approaches combined. This updated analysis corroborates the findings obtained from the search of the five n-grams in books. (see **Figure 1**).

### 5.1.Ecological Economics as a Global Reference

Now the objective is to recognize what makes the analyzed approaches different in terms of scientific production, and to identify patterns in a broad field of study that seeks to link economic issues with the environment.

By analyzing only peer-reviewed scientific publications, we handled a sample with a degree of homogeneity, while ensuring a minimum level of quality and objectivity (in addition to non-repetition of articles). Presumably, members of the scientific community know, accept, and agree to the requirements to be able to publish their contributions in these fields. To carry out the



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comparative analysis among Environmental Economics, Ecological Economics, Circular Economy, Green Economy and Bioeconomy, the following methodological criteria was adopted:

1. Scopus.com search engine was used;
2. Papers published from 2000 onwards were analyzed and 2020 was the end of the analysis period.
3. The search terms employed were *"ecological economics"; "environmental economics"; "bioeconomy"; "green economy" and "circular economy";*
4. Results were restricted to original scientific articles, excluding reviews, book chapters, conference papers, etc.;
5. In the papers, the terms were searched among the fields Title; Keywords, and Abstract. Thus, for example, the search command was as follows: TITLE-ABS-KEY ( bioeconomy ) AND DOCTYPE ( ar ) AND PUBYEAR > 1999

Once the search criteria were applied and the results obtained, the 40 most frequent keywords were selected and ordered on a decreasing basis for each approach. The five tables are presented in **Appendix** for the sake of tidiness in the text. **Tables 1 to 5** of the **Appendix** show the absolute number and frequency of appearance of each keyword in relation to the total number of results for a given term search.

Moreover, the results presented in the **Appendix** were refined following practical criteria: keyword counts such as *"article"* and *"priority journal"* were excluded as they do not contribute to the distinction or characterization of each approach. The frequent appearance of keywords such as *"article"* or *"priority journal"* indicates that the selection authors make is not always effective, at least to represent the content of their manuscripts and the specificity of their fields of study. This may represent a bias in our own analysis methodology. Keywords whose only difference was singular or plural were combined, such as the case of "ecosystem service" and *"ecosystem services".* Ultimately, each table contains a list of the **35 most frequent keywords.**

The first analysis consisted in the processing of data to visualize overlapping areas among the five approaches. **Figure 4** includes the number of keywords that lie in each intersection of the data sets. For example, there are seven keywords that can be found in all five streams addressed here. On the other hand, 16 keywords belong only to the circular economy approach. Green Economy and Environmental Economics share 5 keywords that are not present in the other streams. It is quite



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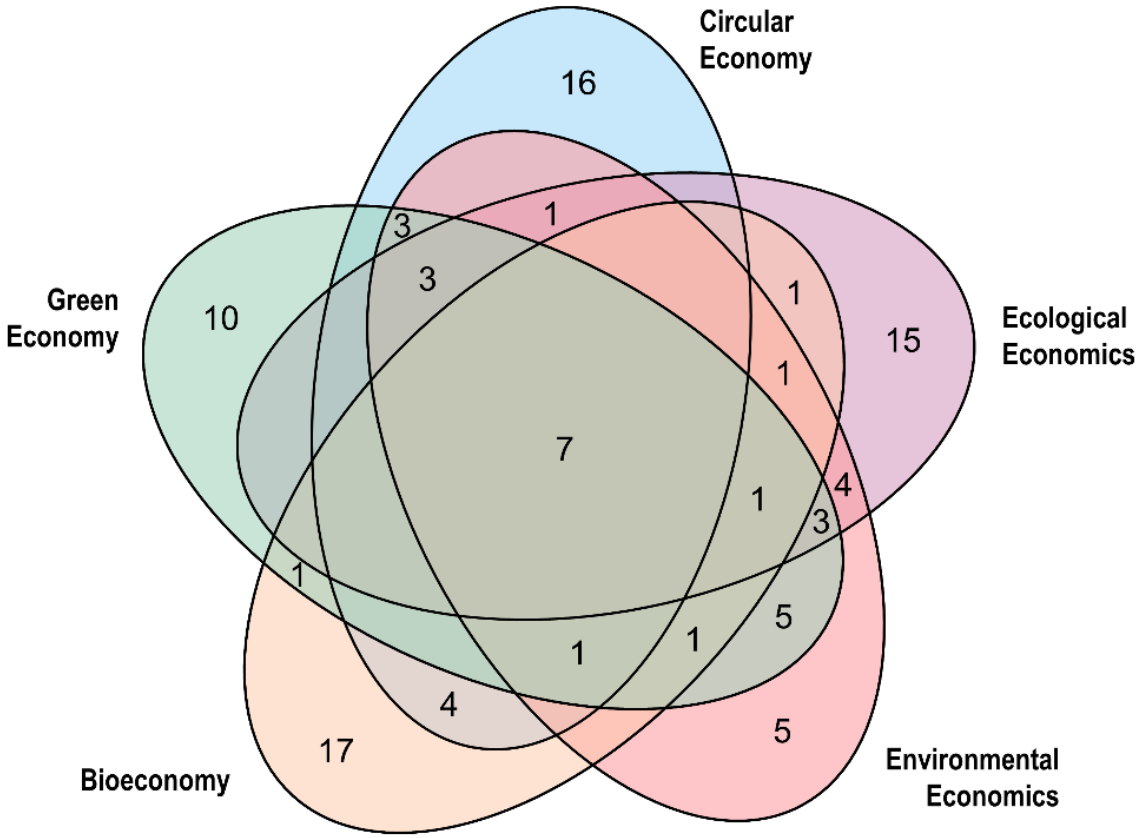
evident that among the five approaches analyzed, Environmental Economics has the least number of keywords (just five) that are exclusive to it.

**Figure 4**. Areas of overlap between streams




Source: Own using Python coding and Google Presentations

A fact of particular interest is to reveal which are the seven common words among all the approaches. The common keywords are Climate Change, Economic Analysis, Economics, Environmental Economics, Environmental Impact, Sustainability, and Sustainable Development. For these seven words, we calculated statistical parameters using their internal frequency of appearance. **Table 1** summarizes the obtained results, and the keywords are ordered according to their inverse-coefficient of variation $CV^{-1} = \bar{x}/_{s.d.}$. [$\bar{x}$: mean value; s.d.: standard deviation].



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**Table 1: internal frequency of appearance of common keywords**

| Keyword | Bioeconomy | Circular | Ecological | Environmental | Green | $CV^{-1}$ |
|---|---|---|---|---|---|---|
| Sustainability | 0.134 | 0.144 | 0.189 | 0.137 | 0.149 | 7.566 |
| Economics | 0.069 | 0.082 | 0.106 | 0.124 | 0.071 | 4.236 |
| Sustainable Development | 0.131 | 0.182 | 0.169 | 0.176 | 0.266 | 4.169 |
| Environmental Impact | 0.037 | 0.075 | 0.044 | 0.085 | 0.026 | 2.354 |
| Economic Analysis | 0.039 | 0.037 | 0.087 | 0.076 | 0.030 | 2.331 |
| Climate Change | 0.064 | 0.033 | 0.058 | 0.132 | 0.085 | 2.239 |
| Environmental Economics | 0.042 | 0.053 | 0.096 | 0.979 | 0.175 | 0.751 |

Source: Own using Google Spreadsheets

The higher the $CV^{-1}$, it means that the keyword is correspondingly relevant (highly used) for the five approaches with minimum relative differences among them. Sustainability as a concept (including Sustainable Development) together with Economics constitute the main indistinguishable topics among the five approaches.

Further analysis was developed and depicted in **Figure 5.** The identification of words that appear in just one of the five approaches is also relevant. It is a simple yet seemly way of visualizing the major similarities and differences between the five lines. In the bags of words in **Figure 5**, each keyword is sized according to its internal frequency of appearance.

Among other findings from the data presented in the tables —that collect the most frequent keywords for each approach— and **Figure 5,** a series of rather general comments can be made.

The cumulative number of articles on Environmental Economics is six times bigger than that of Ecological Economics, and far exceeds any of the other approaches. It should be noted, however, that for Circular Economy, the number of publications is so high in the last two years that it reaches and even exceeds those of Environmental Economics. This reveals the wide topicality it has gained as a concept or approach.

Moreover, it is notorious —although not surprising— that the five approaches analyzed seem to be defined in common by *"sustainability"* and *"sustainable development"*. These keywords appear in all approaches, on average, in the second and third most frequent positions. Sustainability is a *"plastic"* concept, in which all approaches are placed seamlessly**.**



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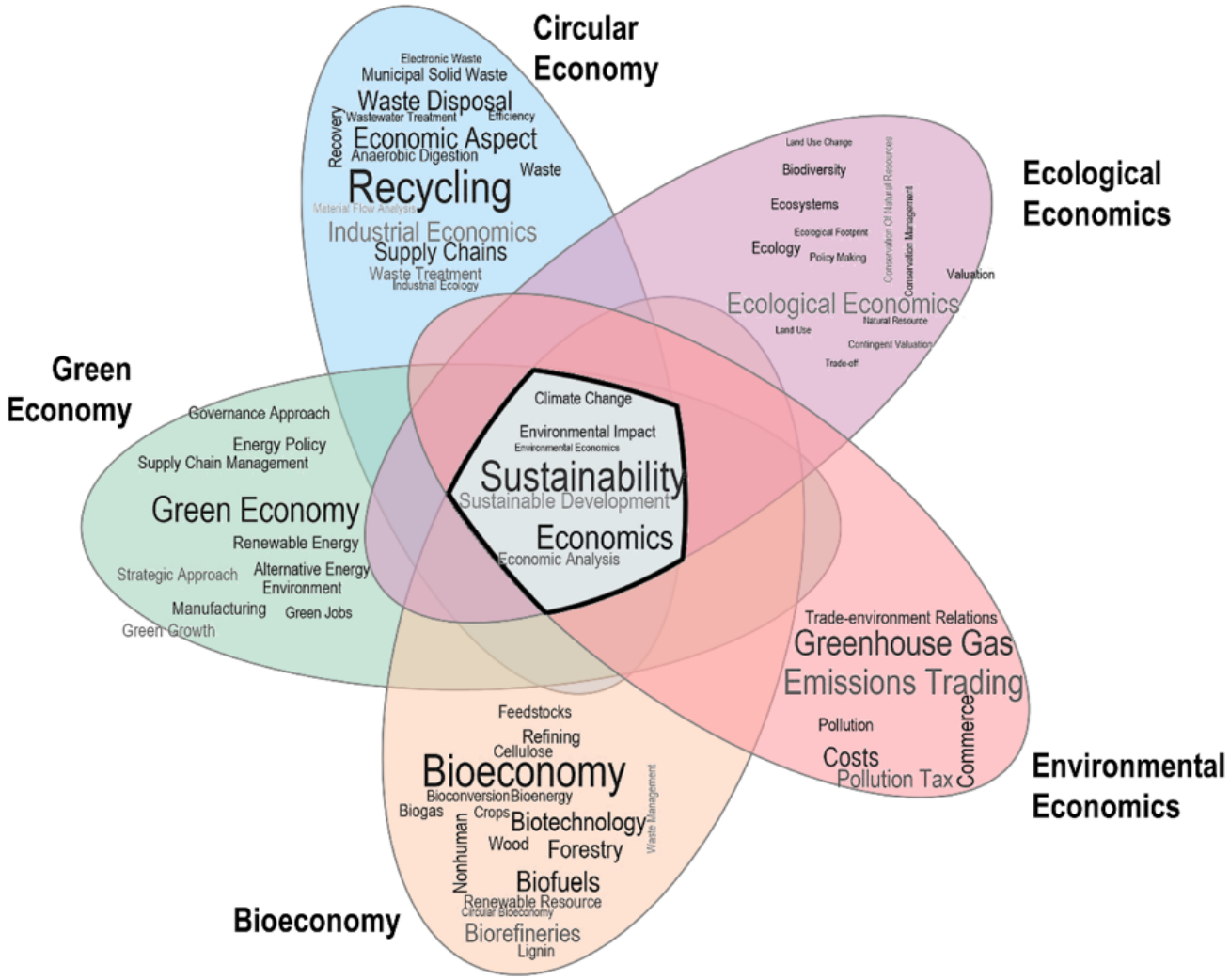
**Figure 5. Schematic clustering view of the keywords**




Source: Own using Python coding and Google Presentations

A third observation is that Environmental Economics, apart from being the very term of search of the approach itself, also appears as a keyword in the other four approaches. Besides, it is one of the most frequent keywords: it is the seventh most frequent for Ecological Economics, the tenth for Circular Economy, the second for Green Economy, and only in the case of Bioeconomy it is a little more relegated, in 22nd place.

Moreover, being Environmental Economics the name of one of the approaches, is the only keyword found in the five lines; then only Circular E Notably, the number of articles on



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Environmental Economics significantly surpasses that of all other approaches combined. This updated analysis corroborates the findings obtained from the search of the five n-grams in books.

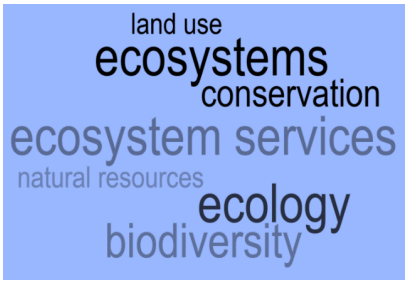
Economy appears both in its own approach and in Bioeconomy. This denotes how permeable Environmental Economics is as regards the other concepts, either by affinity or by being contested from the other approaches.

To shed light on this point, in the next section, we analyze families of words to identify degrees of homogeneity or discrepancy among the five approaches.

### 5.2.Keywords Groupings and Distinctive Features

To identify the degrees of homogeneity or discrepancy among the five approaches, we grouped words for each of the approaches compared. The criterion adopted was that there was certain cohesion among them, which allowed us to identify the distinctive features of the approach. The resulting groupings are by no means the only ones possible and could certainly differ in their content or other groupings might as well be defined. See **Cloud Word 1.**

**Cloud Word 1. Ecological Economics, the following family of words is found.**




Source: Own using Google Presentations

Broadly speaking, this approach seems to be more linked to ecologism and environmental protection, with an emphasis on the structure and functions of ecosystems and biodiversity. Many of these concepts are directly related to pure Ecology, as proposed by Cavalcanti (2010).

However, this family of words is not isolated and, within the 35 organized, refined and classified keywords, it coexists with a great deal of economics-related terms and jargon, such as valuation, cost-benefit analysis, willingness to pay, etc. See **Cloud Word 2.**



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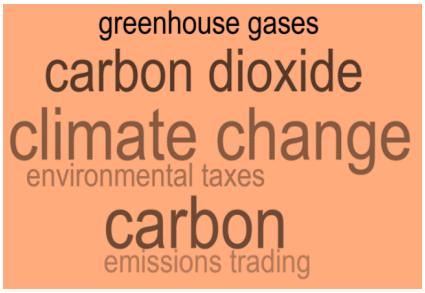
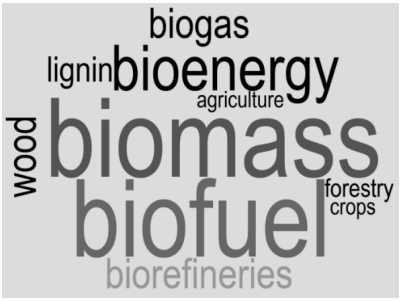
**Cloud Word 2. Environmental Economics**




Source: Own using Google Presentations

Based on this family of words, it can be said that, at least in recent years, Environmental Economics has been oriented to applying tools of economic policies and market instruments as a way to address climate change due to anthropogenic activities. In particular, we would say it has sought to *"internalize"* the environmental impact by expanding the market. See **Cloud Word 3.**

**Cloud Word 3. Bioeconomy**




Source: Own using Google Presentations

As the very name of the approach suggests, this is bio-based economics. Thus, it is recognized, on the one hand, as a specialization of mainstream economics, since it mentions areas that have to do with the primary sector (agriculture, forestry).

On the other, it is evident that there is a fully utilitarian bias towards taking advantage of biological functions as vectors for the development of economic activities, by means of energy use.

In addition, from the global analysis of the 35+ most frequent keywords, it is obvious that Bioeconomy has a more technological orientation and a clearer relationship with industry and



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engineering. Hence, out of the five approaches analyzed, it seems to be the most distant to economics as a discipline, although this does not imply closeness to ecology or the environment. See **Cloud Word 4.**

**Cloud Word 4. Circular Economy**


Source: Own using Google Presentations

As a distinctive approach, Circular Economy clearly points to a technological vision to reuse, treat or recycle waste from the economic activity, namely, processes that transform and treat waste, to reuse it in a new economic cycle. It is also strongly related to economic and environmental management, bearing an unmistakable technological and engineering imprint, although less than Bioeconomy. See **Cloud Word 5.**

**Cloud Word 5. Green Economy**


Source: Own using Google Presentations

Green Economy is the least concrete of the five approaches, although closely related to Environmental Economics, especially as regards climate change. The focus seems to be on



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redirecting investments toward certain types of technologies, particularly those related to energy and efficiency.

### 5.3.Differentiating Ecological Economics from Environmental Economics

Another search exercise for specific terms was carried out. A priori, they would be related to Ecological Economics, but some others would be close to Economics. A Boolean intersection criterion was employed. Each specific term was searched in Scopus within the results for each approach, either Ecological Economics or Environmental Economics alone, which ensured that the results included both search terms simultaneously.

Although it is a slightly different approach to keywords, it is still valid as it allows us to identify similarities and differences between the two approaches.

Specific search terms are ordered according to the rate of appearance over the total of articles within each approach. We have always employed scientific papers from **2000 onwards**. Thus, for example, the term *"poverty"* appears in **342** of **the 2,519** total results for *"ecological economics"*. It represents around 13%.

After obtaining the frequency of appearance for each term within each approach, the quotient between the two was obtained. This way, we obtained a ratio of relative appearances.

Th **Figure 6** summarizes the results. They have been ordered according to the ratio, that is, at a relative frequency of appearance that is higher in Ecological Economics than in Environmental Economics.

From the analysis of the more than **20** specific search terms, a series of interesting results emerges. Except for *"optimal", "efficiency" and "decoupling",* all the other concepts have a higher frequency of appearance in Ecological Economics than in Environmental Economics.

The widely differing concepts in Ecological Economics when compared to Environmental Economics are linked to *"political ecology"* and *"ecological distribution conflicts"*. Approaches to the society-nature interface, such as "social metabolism" and "biophysical indicators" of (un)sustainability, also seem to be comparatively relevant.

Surprisingly enough, the term *"valuation",* which could be presumably more associated with Environmental Economics, is a more frequent term for Ecological Economics.



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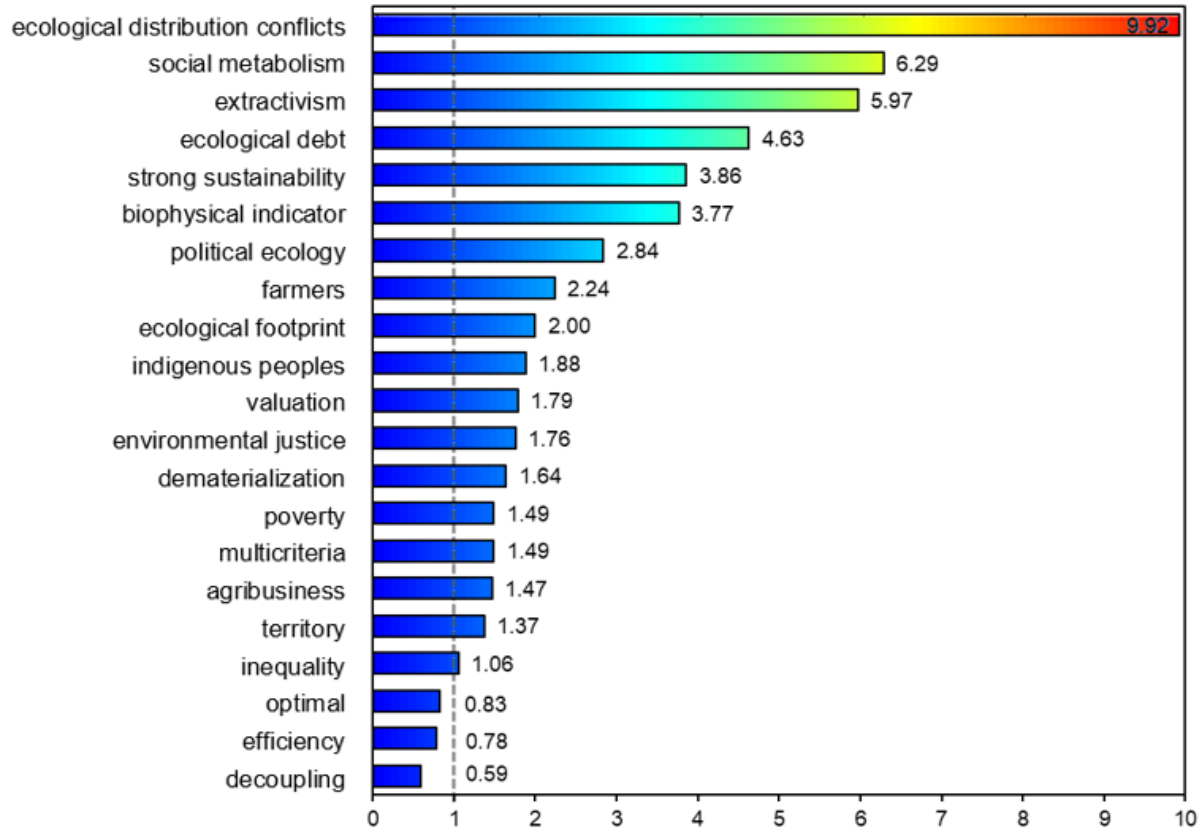
**Figure 6. Ratio of relative appearances of selected concepts**




Source: Own using Google Spreadsheets

## 6. DISCUSSION

This study, although it provides relevant elements for the analysis of the selected streams of thought, has important limitations that must be taken into account when interpreting its results.

First, the analysis was restricted to a single academic database (Scopus, n.d.), which limits the breadth and representativeness of the bibliographic corpus. Some streams, especially those with less international visibility, could be underrepresented or biased in this source. Furthermore, the inclusion of non-indexed literature or technical documents could enrich the overall picture and allow for a more inclusive analysis.

Secondly, the keywords analysis methodology, although rigorous, is not sufficient on its own to capture the practical and contextual dimensions of each current. Therefore, it is recognized that this



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study needs to be complemented with qualitative methodologies (such as expert interviews, and extended content analysis) and quantitative methodologies (such as bibliometric network analysis or thematic meta-analysis) that allow for valuable analysis.

Once our methodological biases are recognized, the discussion about the findings, which we considered consistent, may be addressed.

The research question aimed to determine the extent to which it is possible to conceptually and analytically distinguish five areas that share a common thematic field, and whether these areas constitute autonomous approaches or variants of the same logic. In this sense, the initial hypothesis proposed that, despite the similarities between them, it is possible to identify substantial differences that justify their differentiated treatment in academic and applied analysis.

### 6.1. Theoretical contributions

From a theoretical perspective, the analysis revealed that, while the five currents share a common focus on sustainability, not all possess the same degree of theoretical consolidation or methodological autonomy. Ecological Economics emerges as the most distinctive in terms of conceptual amplitude and critical stance towards conventional economics, justifying its treatment as a specific approach within the field. In contrast, Environmental Economics presents itself as a transitional approach to the environment strongly based on neoclassical economics. The other three currents analyzed (Circular Economy, Green Economy and Bioeconomy) only present nuances of the same conceptualization, with overlapping elements that make it difficult to clearly separate them from Environmental Economics.

### 6.2. Practical contributions

From a practical perspective, these findings allow for improved design and implementation of policies, strategies, or tools based on these approaches. Distinguishing Ecological Economics from Environmental Economics may enrich policymaking discussions: the former prioritizes biophysical limits and comprehensive human well-being, while the latter emphasizes the regulation of externalities and the monetary valuation of resources. This practical nuance allows for the design



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of appropriate instruments: extraction quotas and sufficiency criteria for Ecological Economics; Pigouvian taxes and permit markets for Environmental Economics.

This enhances regulatory effectiveness, avoids generic solutions, and orients sustainability strategies according to the scope and objectives of each discipline. In doing so, it contributes directly to **SDG 8** (*Decent Work and Economic Growth*) by promoting sustainable and inclusive economic strategies, and to **SDG 13** (*Climate Action*) by supporting climate-resilient policy design and the internalization of environmental costs in economic decision-making (United Nations, n.d.).

## 7. CONCLUSION

Current approaches that address the relationship between economic dynamics and the natural environment have diversified significantly over the past decade. Ecological Economics—as a transdisciplinary and critical alternative to mainstream economics—and Environmental Economics—as a recognized branch of orthodox economics—can be considered two distinct *"schools"*. Their historical depth and the breadth of their thematic agendas distinguish them from other approaches such as Circular Economy, Green Economy, and Bioeconomy. Among these, Environmental Economics exhibits an enveloping and evolving nature, often intersecting with other currents, including Ecological Economics. This supports the view that Environmental Economics remains the dominant paradigm.

Circular Economy, Green Economy, and Bioeconomy do not exhibit substantial theoretical or instrumental departures from the core assumptions of Environmental Economics. Their focus is sectoral and operational, lacking a structural critique of the economic system. Notably, they emphasize technological and productive components—particularly in Bioeconomy and Circular Economy—while Green Economy remains conceptually diffuse and difficult to delimit from Environmental Economics.

Within Ecological Economics itself, current research reveals internal variation. Leading academic platforms—such as the Ecological Economics journal—include numerous contributions that align more closely with the Environmental Economics framework. This includes applications of neoclassical tools such as Pigouvian externalities and market-based mechanisms for internalizing environmental costs. However, our lexical and conceptual analysis highlights terms that strongly differentiate Ecological Economics, including political ecology, ecological



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distribution conflicts, social metabolism, and biophysical indicators of (un)sustainability. Interestingly, the term *"valuation",* traditionally linked to Environmental Economics, frequently appears in Ecological Economics literature as well.

In synthesis, this analysis reinforces the idea that while Environmental Economics—along with Green Economy, Circular Economy, and Bioeconomy—seeks to economize ecology, Ecological Economics aims to ecologize economics. This tension, while productive, remains embedded in internal contradictions. These findings contribute new knowledge to the field by clarifying conceptual boundaries and overlaps that often create confusion among scholars and practitioners alike. They offer a foundation for advancing a more coherent, multidisciplinary, and innovation-oriented agenda for sustainability. In doing so, they support SDG 8 (Decent Work and Economic Growth) by encouraging structural economic transformation, and SDG 13 (Climate Action) by promoting frameworks that prioritize planetary boundaries and ecological integrity in economic decision-making (United Nations, n.d.).

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix

**Table 1. Keywords order for *Ecological Economics***

| Order | Keyword | Count | Frequency |
|---|---|---|---|
| 1 | Ecological Economics | 2252 | 89.7% |
| 2 | Ecosystem Services | 535 | 21.3% |
| 3 | Sustainability | 474 | 18.9% |
| 4 | Sustainable Development | 423 | 16.9% |
| 5 | China | 347 | 13.8% |
| 6 | Ecology | 269 | 10.7% |
| 7 | Economics | 267 | 10.6% |
| 8 | Environmental Economics | 241 | 9.6% |
| 9 | Ecosystems | 233 | 9.3% |
| 10 | Biodiversity | 227 | 9.0% |
| 11 | Economic Analysis | 218 | 8.7% |
| 12 | Environmental Protection | 207 | 8.2% |
| 13 | Cost-benefit Analysis | 197 | 7.8% |
| 14 | Valuation | 181 | 7.2% |
| 15 | United States | 173 | 6.9% |
| 16 | Decision Making | 168 | 6.7% |
| 17 | Climate Change | 146 | 5.8% |
| 18 | Environmental Policy | 142 | 5.7% |
| 19 | Willingness To Pay | 136 | 5.4% |
| 20 | Economic Growth | 131 | 5.2% |
| 21 | Economic Development | 129 | 5.1% |
| 22 | Numerical Model | 125 | 5.0% |
| 23 | Conservation Management | 113 | 4.5% |
| 24 | Eurasia | 112 | 4.5% |
| 25 | Environmental Impact | 110 | 4.4% |
| 26 | Policy Making | 108 | 4.3% |
| 27 | Conservation Of Natural Resources | 107 | 4.3% |
| 28 | Agriculture | 105 | 4.2% |
| 29 | Contingent Valuation | 96 | 3.8% |
| 30 | Land Use | 94 | 3.7% |
| 31 | Land Use Change | 89 | 3.5% |



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| | | | |
|---|---|---|---|
| 32 | Theoretical Study | 86 | 3.4% |
| 33 | Europe | 84 | 3.3% |
| 34 | Natural Resource | 84 | 3.3% |
| 35 | Ecological Footprint | 82 | 3.3% |

Source: Own elaboration.

**Table 2. Keywords order for *Environmental Economics***

| Order | Keyword | Count | Frequency |
|---|---|---|---|
| 1 | Environmental Economics | 15885 | 97.9% |
| 2 | Sustainable Development | 2859 | 17.6% |
| 3 | Carbon Emission | 2654 | 16.4% |
| 4 | China | 2628 | 16.2% |
| 5 | Environmental Policy | 2292 | 14.1% |
| 6 | Sustainability | 2229 | 13.7% |
| 7 | Climate Change | 2134 | 13.2% |
| 8 | Emission Control | 2124 | 13.1% |
| 9 | Carbon Dioxide | 2077 | 12.8% |
| 10 | Cost-benefit Analysis | 2075 | 12.8% |
| 11 | Greenhouse Gases | 2070 | 12.8% |
| 12 | Environmental Protection | 2046 | 12.6% |
| 13 | Economics | 2019 | 12.4% |
| 14 | United States | 1402 | 8.6% |
| 15 | Environmental Impact | 1385 | 8.5% |
| 16 | Investments | 1384 | 8.5% |
| 17 | Economic Growth | 1365 | 8.4% |
| 18 | Economic Development | 1300 | 8.0% |
| 19 | Environmental Management | 1239 | 7.6% |
| 20 | Economic Analysis | 1238 | 7.6% |
| 21 | Emissions Trading | 1163 | 7.2% |
| 22 | Decision Making | 1086 | 6.7% |
| 23 | Costs | 1030 | 6.3% |
| 24 | Carbon | 1028 | 6.3% |
| 25 | Ecosystem Service | 986 | 6.1% |
| 26 | Pollution Tax | 913 | 5.6% |
| 27 | Willingness To Pay | 847 | 5.2% |



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| | | | |
|---|---|---|---|
| 28 | Commerce | 828 | 5.1% |
| 29 | Europe | 826 | 5.1% |
| 30 | Trade-environment Relations | 790 | 4.9% |
| 31 | Human | 788 | 4.9% |
| 32 | Numerical Model | 737 | 4.5% |
| 33 | Economic And Social Effects | 726 | 4.5% |
| 34 | Energy Efficiency | 698 | 4.3% |
| 35 | European Union | 682 | 4.2% |

Source: Own elaboration

**Table 3. Keywords order for *Green Economy***

| Order | Keyword | Count | Frequency |
|---|---|---|---|
| 1 | Green Economy | 1273 | 68.3% |
| 2 | Sustainable Development | 496 | 26.6% |
| 3 | Environmental Economics | 327 | 17.5% |
| 4 | Sustainability | 278 | 14.9% |
| 5 | China | 226 | 12.1% |
| 6 | Climate Change | 159 | 8.5% |
| 7 | Innovation | 151 | 8.1% |
| 8 | Environmental Protection | 147 | 7.9% |
| 9 | Economics | 132 | 7.1% |
| 10 | Economic Growth | 129 | 6.9% |
| 11 | Economic Development | 126 | 6.8% |
| 12 | Investments | 115 | 6.2% |
| 13 | Environmental Policy | 100 | 5.4% |
| 14 | Environmental Management | 99 | 5.3% |
| 15 | Human | 76 | 4.1% |
| 16 | Energy Efficiency | 75 | 4.0% |
| 17 | Carbon Emission | 72 | 3.9% |
| 18 | Energy Policy | 68 | 3.6% |
| 19 | Green Growth | 66 | 3.5% |
| 20 | Manufacturing | 65 | 3.5% |
| 21 | Decision Making | 63 | 3.4% |
| 22 | Governance Approach | 62 | 3.3% |



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| | | | |
|---|---|---|---|
| 23 | Renewable Energy | 62 | 3.3% |
| 24 | Emission Control | 60 | 3.2% |
| 25 | Carbon | 59 | 3.2% |
| 26 | Alternative Energy | 58 | 3.1% |
| 27 | Strategic Approach | 58 | 3.1% |
| 28 | Supply Chain Management | 58 | 3.1% |
| 29 | Economic And Social Effects | 57 | 3.1% |
| 30 | Economic Analysis | 55 | 3.0% |
| 31 | United States | 55 | 3.0% |
| 32 | Environment | 54 | 2.9% |
| 33 | Carbon Dioxide | 51 | 2.7% |
| 34 | Commerce | 49 | 2.6% |
| 35 | Environmental Impact | 48 | 2.6% |

Source: Own elaboration

**Table 4. Keywords order for *Circular Economy***

| Order | Keyword | Count | Frequency |
|---|---|---|---|
| 1 | Circular Economy | 3224 | 63.9% |
| 2 | Life Cycle Analysis | 1092 | 21.6% |
| 3 | Recycling | 1055 | 20.9% |
| 4 | Sustainable Development | 920 | 18.2% |
| 5 | Sustainability | 727 | 14.4% |
| 6 | Waste Management | 706 | 14.0% |
| 7 | Economics | 414 | 8.2% |
| 8 | Environmental Impact | 380 | 7.5% |
| 9 | Environmental Economics | 269 | 5.3% |
| 10 | Economic Aspect | 251 | 5.0% |
| 11 | Human | 231 | 4.6% |
| 12 | Waste Disposal | 225 | 4.5% |
| 13 | Industrial Economics | 222 | 4.4% |
| 14 | Decision Making | 213 | 4.2% |
| 15 | China | 211 | 4.2% |
| 16 | Controlled Study | 209 | 4.1% |
| 17 | Biomass | 204 | 4.0% |
| 18 | Economic Analysis | 189 | 3.7% |



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| | | | |
|---|---|---|---|
| 19 | Economic And Social Effects | 188 | 3.7% |
| 20 | Municipal Solid Waste | 188 | 3.7% |
| 21 | Waste | 185 | 3.7% |
| 22 | Environmental Management | 183 | 3.6% |
| 23 | Supply Chains | 182 | 3.6% |
| 24 | Waste Treatment | 180 | 3.6% |
| 25 | Recovery | 175 | 3.5% |
| 26 | Carbon Dioxide | 171 | 3.4% |
| 27 | Climate Change | 165 | 3.3% |
| 28 | Wastewater Treatment | 164 | 3.2% |
| 29 | Anaerobic Digestion | 161 | 3.2% |
| 30 | Environmental Protection | 156 | 3.1% |
| 31 | European Union | 155 | 3.1% |
| 32 | Material Flow Analysis | 147 | 2.9% |
| 33 | Efficiency | 146 | 2.9% |
| 34 | Nonhuman | 146 | 2.9% |
| 35 | Industrial Ecology | 143 | 2.8% |

Source: Own elaboration

**Table 5. Keywords order for *Bioeconomy***

| Order | Keyword | Count | Frequency |
|---|---|---|---|
| 1 | Bioeconomy | 652 | 51.9% |
| 2 | Biomass | 264 | 21.0% |
| 3 | Sustainability | 168 | 13.4% |
| 4 | Sustainable Development | 165 | 13.1% |
| 5 | Biofuels | 162 | 12.9% |
| 6 | Bioenergy | 161 | 12.8% |
| 7 | Biotechnology | 140 | 11.1% |
| 8 | Biorefinery | 129 | 10.3% |
| 9 | Forestry | 115 | 9.2% |
| 10 | Economics | 87 | 6.9% |
| 11 | Innovation | 81 | 6.4% |
| 12 | Climate Change | 80 | 6.4% |
| 13 | Agriculture | 79 | 6.3% |



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| | | | |
|---|---|---|---|
| 14 | Nonhuman | 77 | 6.1% |
| 15 | Circular Economy | 73 | 5.8% |
| 16 | Refining | 64 | 5.1% |
| 17 | European Union | 64 | 5.1% |
| 18 | Wood | 63 | 5.0% |
| 19 | Europe | 60 | 4.8% |
| 20 | Human | 59 | 4.7% |
| 21 | Cellulose | 56 | 4.5% |
| 22 | Environmental Economics | 53 | 4.2% |
| 23 | Feedstocks | 52 | 4.1% |
| 24 | Renewable Resource | 51 | 4.1% |
| 25 | Metabolism | 50 | 4.0% |
| 26 | Biogas | 50 | 4.0% |
| 27 | Lignin | 50 | 4.0% |
| 28 | Economic Analysis | 49 | 3.9% |
| 29 | Carbon | 48 | 3.8% |
| 30 | Life Cycle | 47 | 3.7% |
| 31 | Economic Development | 47 | 3.7% |
| 32 | Environmental Impact | 46 | 3.7% |
| 33 | Germany | 44 | 3.5% |
| 34 | Crops | 43 | 3.4% |
| 35 | Chemistry | 43 | 3.4% |

Source: Own elaboration

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