The Role of Green Innovation in Sustainable Entrepreneurship: A Bibliometric Analysis and Methodological Approach

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Abstract. Climate change presents a new set of challenges that are reshaping regulatory and competitive landscapes, driven by global policy initiatives aimed at reducing carbon emissions and in response to the increasing severity of climate-related events. These changes necessitate rapid societal adaptation to emerging circumstances, as climate change triggers profound transformations within socio-economic systems. As environmental concerns grow, businesses are adopting sustainable practices and making strategic investments in low-CO2 technologies and renewable energy. To examine the evolving landscape of sustainable entrepreneurship in response to green innovation, this study provides a comprehensive bibliometric analysis of research from the last decade, utilizing VOS viewer and Biblioshiny software. The analysis focuses on identifying publication trends, highly cited papers and journals, influential countries and authors, and common themes in this field. Findings indicate a significant rise in publications over the past decade, signaling growing recognition of green innovation's pivotal role in advancing sustainable entrepreneurship. Geographic analysis highlights substantial contributions from the US, India, and China, underscoring the global relevance of green innovation in sustainability. The study identifies critical research gaps and provides valuable insights for scholars, entrepreneurs, and policymakers aiming to foster sustainable business practices through innovation.

Keywords: Green Innovation, Sustainable Entrepreneurship, Bibliometric Analysis, Eco-Innovation, Circular Economy, Methodological Trends.

1. Introduction

Climate change presents a new set of difficulties reshaping regulatory and competitive areas [1]. This is being done not only through global policy initiatives aimed at reducing carbon emissions but also as an immediate reaction to the devastation caused by severe climate phenomena [2]. Moreover, modern societies are facing danger to their survival and stability due to climate change [3]. There is an increase in the number of individuals succumbing to starvation and facing poverty [4,5]. Gender disparities and unequal access to resources and opportunities persist, and the wealth gap is increasing [6].

Climate change engenders unparalleled transformations within socioeconomic systems, thereby necessitating an immediate societal response and adjustment to emerging circumstances [7]. As environmental concerns grow, businesses are taking action by adopting sustainable practices and making strategic investments in low-CO2 technologies and renewable energy [8,9,10].

These issues varying degrees depending on the situation, have added to the demand for sustainable entrepreneurship. Muñoz [11] emphasizes the importance of viewing entrepreneurship as a means to address environmental degradation and social inequality, rather than contributing to these issues. This perspective has prompted researchers to explore a new form of entrepreneurial activity. Entrepreneurs committed to sustainability elevate conventional business practices by introducing innovative products and services related to social and environmental issues [12,13]. In this case, the existing production techniques, products, market structures, and consumption patterns that are not sustainable are replaced with more sustainable alternatives.

Recognizing the important role of businesses in society and the effects of their practices, entrepreneurship plays a vital role in moving towards a more sustainable future [14]. When sustainability is integrated with entrepreneurship, it involves considering environmental protection, natural resource conservation, and poverty reduction [15,16]. The goal of entrepreneurs is to incorporate sustainable practices into their business creation, driving and impacting sustainable development [17,18]. These factors have significant effects on the economy, society, and the environment [19,20].

Given the increasing focus and importance of Sustainable Entrepreneurship, this study seeks to analyze the literature using bibliometric methods to analyze the trends specifically in green innovation within sustainable entrepreneurship. Bibliometrics is an area of research that utilizes statistical and mathematical methods to evaluate scientific activity [21]. Bibliometric analysis is the application of statistical instruments that enable the quantification of scientific output. By directing attention toward various factors that contribute to the delineation of a particular academic discipline, like journals, publications, languages, countries, and institutions, they imbue the subjective evaluation of the literature with a quantitative framework [22-26]. In today s digital era, novel

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measures have been established (such as download statistics and page ranks) that simplify the analysis of scientific output in several manners [21]. Bibliometric approaches can establish a systematic, clear, and reproducible review process, hence enhancing the quality of reviews. They serve as an invaluable instrument in literature reviews by directing the researcher to the most significant publications and outlining the research landscape, minimizing subjective bias. They enable researchers to ground their conclusions in aggregated bibliographic data generated by other scientists, encompassing citation, collaboration, or authorship. The examination of this aggregate data enables academics to investigate the field's structure, social networks, and primary topics [22].

This study aimed to carry out a bibliometric analysis of articles about green innovation in Sustainable Entrepreneurship, as indexed in the Scopus database. A quantitative methodology was employed to do a bibliometric analysis of published publications to fulfill this aim. This research utilizes Bibliometrix, an R package featuring a web-based interface called Biblioshiny, along with VOSviewer for bibliometric analysis [23,24]. The identification of significant research sites will facilitate the formulation of policies that foster sustainable research. Moreover, the visualized data or evidence can be utilized to examine the historical record of research output in a certain domain and identify prospective future research directions and collaboration affiliations [25,26].

The first section of the paper starts with this introduction which provides brief contextualization. The second section of the study highlights the research questions and research methods employed in the study. Then the third section explains the results. Section four is the discussion and findings of the research. The fifth section then completes the paper with some suggestions for future work on Green Innovation and Sustainable Entrepreneurship.

2. Methodology

2.1. Research Questions

The primary RQs of this investigation are:

RQ1: What is the volume of research on the intersection of green innovation and sustainable entrepreneurship?

RQ2: What are the Publication Sources Information and the Most Productive Source?

RQ3: What is the intellectual structure of knowledge based on Sustainable Entrepreneurship?

RQ4: Which institutions and nations contributed most to the knowledge base on green innovation within sustainable entrepreneurship?

RQ5: What are the key concepts or themes explored on the topic of green innovation within Sustainable entrepreneurship and how are they related?

RQ6: What methodological approaches are predominantly used in this filed?

2.2. Search Strategies

To find the answers to the stated Research Questions, a sample of published articles from Scopus was used to understand Green Innovation within Sustainable Entrepreneurship. Scopus was chosen as it aggregates the most influential journals in the field of social sciences and its comprehensive coverage as one of the leading bibliographic databases. Scopus precisely shows the number of citations received [27]. Moreover, Elsevier (2015) collaborates with institutions and experts to advance the field of science, enhancing its efficacy for the betterment of mankind. Furthermore, the Scopus database is the most extensive collection of abstracts and references of scholarly articles.

The search was conducted using the following parameters: (TITLE-ABS-KEY ("Green Innovation" OR "Eco-Innovation" OR "Environmental Innovation") AND TITLE-ABS-KEY ("Sustainab* Entrepreneur*" OR "Green Economy")). The asterisk (*) was selected because it encompasses all possible combinations of characters related to Sustainable entrepreneurship, including all synonyms found in the "title, abstract, and keywords". The search was performed in September 2024, and all relevant papers were published on the topic of green innovation in sustainable entrepreneurship up to the year 2024, without restricting the time period. The criteria for delimiting the topic were as follows: (a) All articles, Conference Proceedings, and reviews were included; (b) all thematic areas were examined; and (c) all countries/territories were included, as long as they were in English. The process of data analysis and search approach is explained in Figure 1 and Figure 2.

A document preprocessing procedure was conducted to minimize any noise, duplication, and errors in the article's metadata inside the Scopus database. The final sample consisted of 775 articles. The data was downloaded in CSV and RIS formats and analyzed using Microsoft Excel 365. After processing the data, the analysis was conducted using VOSviewer 1.6.20 and Biblioshiny. VOSviewer [28] is a robust tool that allows for the illustration, visualization, and exploration of scientific maps [29]. Additionally, it enables the display of graphical

maps which help in the analysis and comprehension of the connections between nations, institutions, journals, authors, and keywords [30,31]. Biblioshiny for bibliometrix [32] is a program written in Java created by Massimo Aria at the University of Naples Federico. Biblioshiny integrates the capabilities of the bibliometrix package with the user-friendly interface of web applications under the Shiny package framework. The Bibliometrix R package was first installed and subsequently loaded in R Studio. The Biblioshiny application was initiated by entering Biblioshiny() into the R package.

Figure 1: Process of Data Analysis

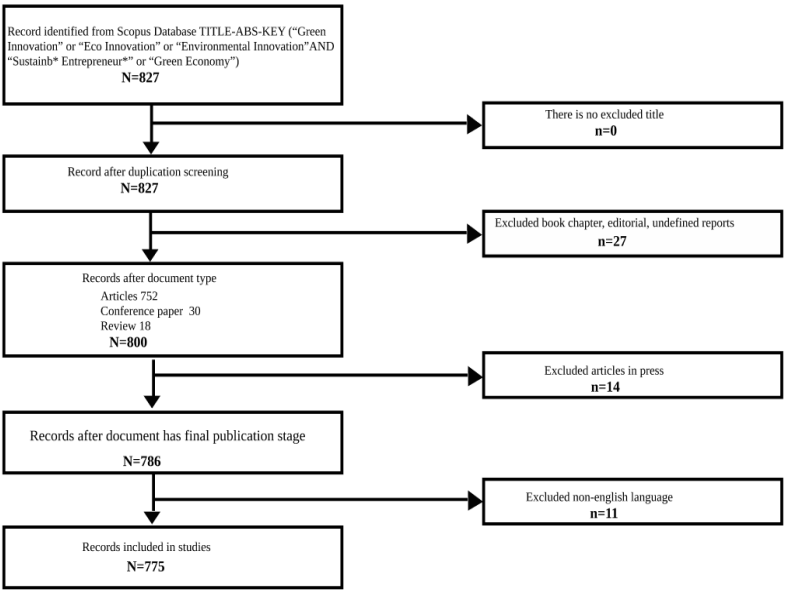

Figure 2: Flow Chart of Search Approach

3. Results

3.1. General Information

Table 1 displays a concise overview of the results from the Scopus. The general information describes the scientific information of the samples used in this study. The number of documents retrieved from searched keywords is 775 scientific documents that are retrieved from 180 Sources. It includes 729 articles, 30 conference papers, and 16 reviews

Table 1: Data Summary of Samples

Description	Results
Total final sample (Papers)	775
Total Authors	1785
Total Sources	180
Total keywords	3997
Total Citations	20306
Total Countries	83
Total Affiliations	1822
Document Types	
Articles	729
Conference Paper	30
Review	16

3.2. Trend Publication

The publication trend of documents in bibliometric analysis of green innovation with sustainable entrepreneurship is shown in Figure 3. Although we did not specify any time period for the conduct of this bibliometric study, our findings reveal that work in the selected keywords commenced in the year 2009. Before that date, no published papers existed related to the selected keywords.

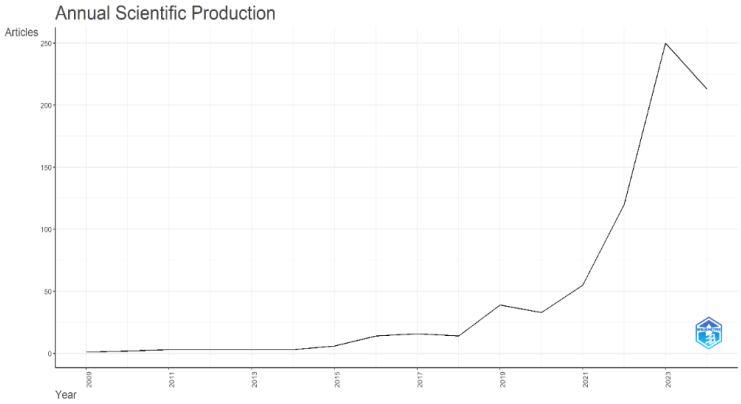

Figure 3: Annual Scientific Production of the Documents

Based on this, we can say that the study covers the years from 2009 to 2024. In addition, the trend number of publications on this study topic grew significantly from the beginning of 2022 to 2024. Through our research, we

can say that the year 2023 has the most articles (250) about green innovation in Sustainable Entrepreneurship. This demonstrates the tremendous attention scholars worldwide have given the innovation and Sustainable Entrepreneurship.

3.3. Publication Sources Information and the Most Productive Source

Figure 4 illustrates Bradford's law. Bradford's law defines the distribution of papers within a field across many journals, indicating that the majority of articles are concentrated in core journals [33]. The findings indicate that there are large numbers of journals that publish a limited number of documents [34]. As shown in Figure 4, Bradford's law indicates that the core journals that have published most in sustainable entrepreneurship include Sustainability (Switzerland), Environmental Science and Pollution Research, and Resources Policy.

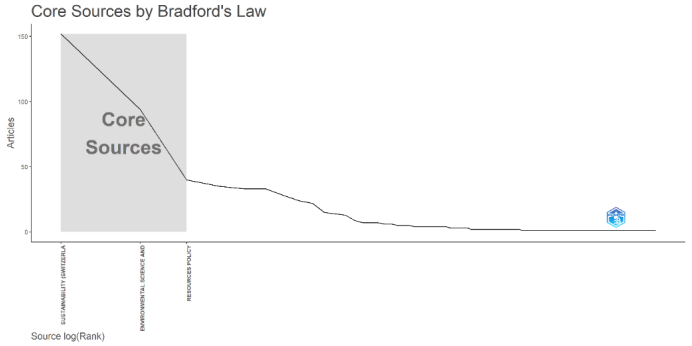

Figure 4: Bradford's Law

Table 2: Top 10 Publication Venues (Ranked as per number of Publications)

Source	Documents	Citations	Cite Score	SJR	SNIP
Sustainability (Switzerland)	176	3113	6.8	0.672	1.086
Environmental science and pollution research	94	1479	8.7	1.006	1.141
Resources Policy	40	599	13.4	2.063	2.083
Journal of Environmental Management	35	1336	13.7	1.771	1.719
Business strategy and the environment	33	2223	22.5	3.666	3.043
International journal of environmental research and public health	33	737	7.3	0.808	1.077
Technological forecasting and social change	28	2368	21.3	3.118	2.945
Energy Economics	22	753	18.6	3.555	2.637
Environment, development, and sustainability	15	142	10.2	0.889	1.297
Journal of Cleaner Production	14	1056	20.4	2.058	2.236

Furthermore, in Table 2, We have seen an increasing level of popularity for Sustainable Entrepreneurship in several academic publications. 180 journals have published 775 papers in this discipline, demonstrating the

publisher's strong interest in this developing area. Table 2 displays the ten most prominent publishing sites in this field of research during the search period. These venues have published at least five documents and are ranked based on the number of documents they have published. The Sustainability (Switzerland) has had 176 published documents, making it the most productive source. It is followed by environmental science and pollution research with 94 documents, resources policy with 40 documents, Journal of Environmental Management with 35 documents, and Business Strategy and the Environment with 33 documents. Conversely, the Business Strategy and the Environment achieved the greatest CiteScore (22.5) out of the top 10 publishing venues according to Scopus criteria. CiteScore quantifies the average number of citations that a serial receives for each document released. The SCImago Journal Rank quantifies the impact of a periodical by considering the weighted citations it receives. The weighting of citations is influenced by the topic area and the prestige (SJR) of the periodical that is doing the referencing. Source Normalized Impact per Paper quantifies the number of citations a paper receives in relation to the number of citations that would be anticipated for its topic area.

3.4. Most Contributing Authors

Lotka's law examines the frequency of journal articles or documents authored, dependent upon the study's focus [35]. From Figure 5, it can be determined that the study involved numerous authors, with approximately 1410 authors contributing a single document each, representing 79% of total author contributions. Figure 6 highlights the production of the ten most prolific authors in the domain of green innovation within sustainable entrepreneurship. The findings indicate that Wang, Y. is the leading contributor from 2017 to 2024, with 21 documents and 514 citations. The second most prolific author in this research area is Zhang, Y., who published 19 documents between 2017 and 2023, gaining 431 citations. The third most prominent author is Zhang, J., with 18 articles and 325 citations, published from 2011 to 2012 and from 2021 to 2024. Li, Y. ranks fourth, while Chen, J. is fifth in terms of publication output.

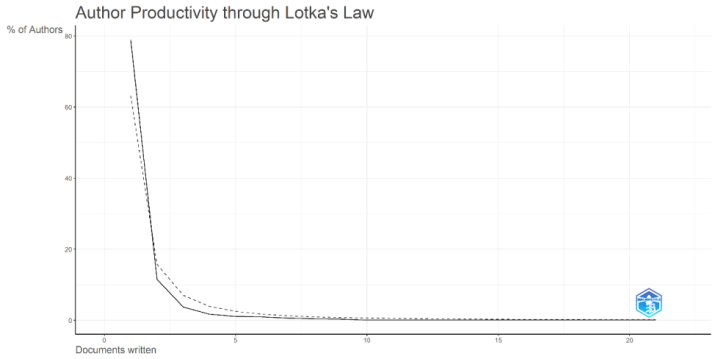

Figure 5: Lotka's Law

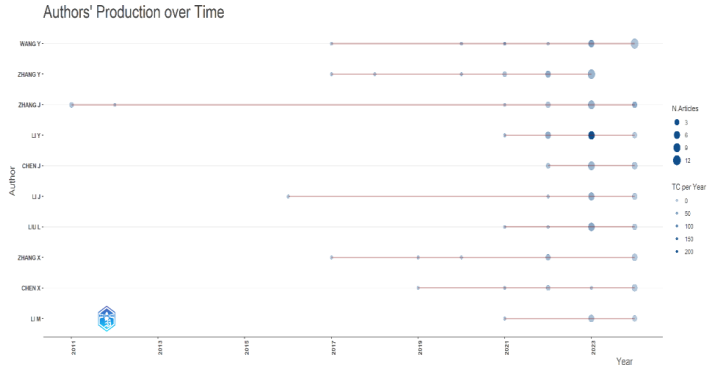

Figure 6: Author's Production over time

Figure 7 represents the distribution of scientific documents according to institutes or affiliations. The study indicates that ten universities have the highest publication production in the area of study. With 63 documented articles, Jiangsu University in China occupies the first position since it is the top institution in scientific publication. China University of Geosciences figures second in scientific publications with 28 articles. Also, the Southwestern University of Finance and Economics in China and Xinjiang University in China are ranked third and fourth institutions with 27 and 24 articles respectively. There are also Jilin University of China and Wuhan University of China type universities whereby 23 articles were published. Central South University and China University of Mining and Technology published 22 and 21 articles in that order. The last institutions that published articles were King Faisal University in Saudi Arabia, and Shandong Normal University in China, each of which had 18 publications.

Additionally, Figure 8 shows the worldwide distribution of sustainable Entrepreneurship publications. The research on Green Innovation in Sustainable Entrepreneurship is extensively spread worldwide. The color trends have depicted the countries based on the volume of work published. According to Figure 8, the documents were provided by the ten countries with the highest contributions to scientific literature. China is the most productive country, resulting in 532 document papers. Pakistan has 54 documents, followed by the United Kingdom has 43 documents. Italy ranks fourth, encompassing 33 documents. The United States has 32 documents, followed by Saudi Arabia with 30 documents, Malaysia with 27 documents, and India with 24 documents. Furthermore, Turkey published 22 documents, while the Russian Federation issued 21 scientific documents.

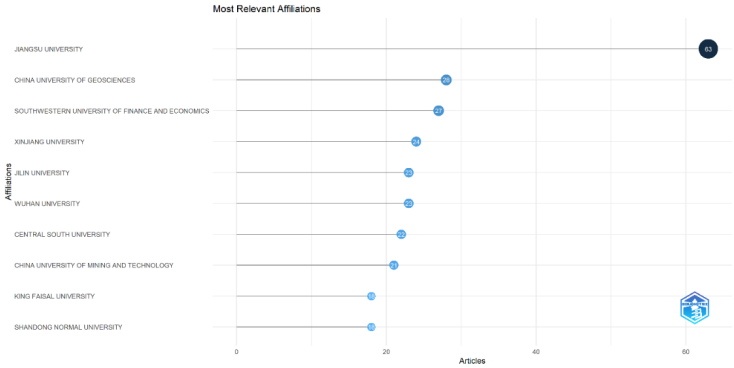

Figure 7: Most Relevant Affiliations

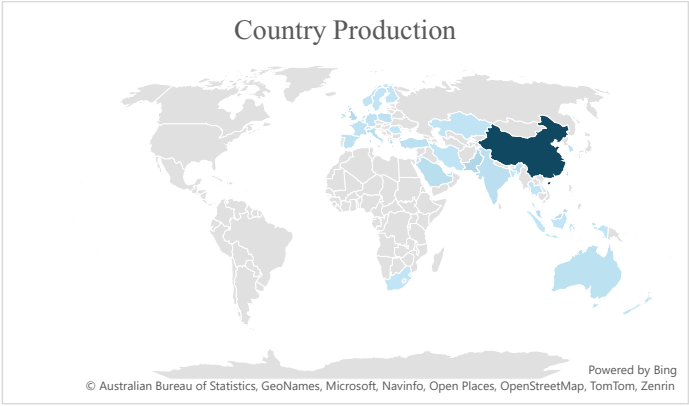

Figure 8: Worldwide Publications

3.6. The Most Frequent Words

The term "China" was used most frequently by authors, occurring 677 times, while "Green Economy" followed very closely with 634 occurrences, as shown in Figure 9. In Figure 9, the larger term indicates a greater frequency of occurrences; conversely, a smaller keyword indicates fewer occurrences. The annual frequency of all key terms increased with time, while some increased faster than others. The terms "Innovation," "Economic Development," and "Sustainable Development" showed the most significant increase in frequency, as seen by a word cloud (Figure 10).

Figure 11 represents hierarchical data in a series of nested rectangles and each group is represented by a rectangle whose area is proportional to the value used for the most frequent words. The result shows that the authors used keywords to represent the size of the word in the abstract of the papers. The more significantly sized words are representative of the frequency that the word is used by authors in the abstract. From Figure 11, we can conclude that the term "China" is the most considerable size in this study, and the frequency of the term is 677 or 13%. It means that the authors used it as the most frequent term for Green Innovation within Sustainable Entrepreneurship. Furthermore, the authors used the word "green economy" in the papers as many as 634 times (12%). In addition, the third position in the treemap is the word "innovation", with a frequency of 477 (9%).

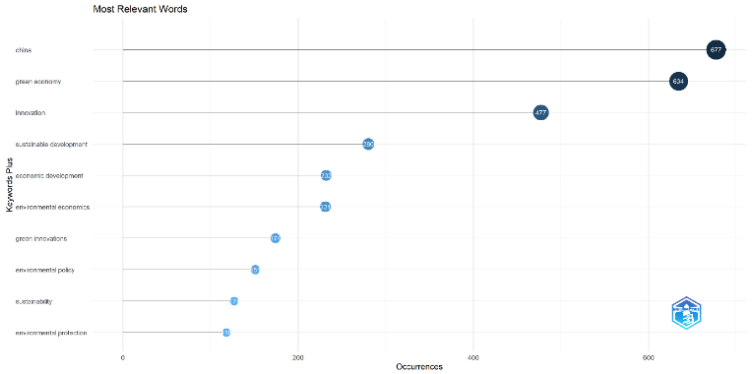

Figure 9: The Most Frequent Used Words

Figure 10: Keywords Cloud

Figure 11: TreeMap of Keywords

3.7. Thematic Map

Academic research themes can be visualized and analyzed in a number of ways, such as through the use of theme maps [36]. The coordinate system is composed of the x- and y-axes for centrality and density, which split the cluster distribution into four quadrants according to the theme map. Themes are collections of keywords that can be mapped into a two-dimensional image by using their density and centrality to arrange them into a single circle. A thematic map is shown in Figure 12, where topics are categorized by the quadrant in which they are located, starting with basic concepts in the bottom-right quadrant and motor themes in the top-right quadrant. The bottom-left quadrant pertains to emerging or vanishing themes, whereas the top-left quadrant is occupied by highly specialized/niche topics. Table 3 displays the data for keywords in publications about green innovation within sustainable development along with their typical measurements.

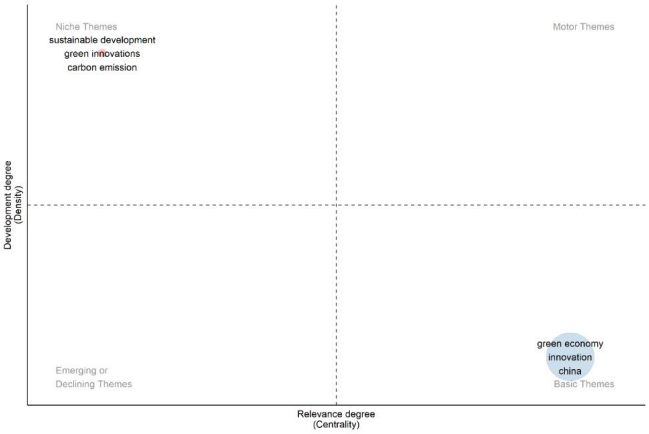

Figure 12: Thematic Mapping

Figure 12 shows that there are no themes in quadrant 1 “motor themes” (top right), nor quadrant 3 “emerging or declining themes” (bottom left). In the 2nd quadrant of “niche themes” (top left position) there are “sustainable development”, “green innovations” and “carbon emission” themes. Niche themes indicate topics that have a lower degree of relevance (centrality) but a higher degree of development (density). The niche themes are located in the top left quadrant, suggesting that while they may not have a wide-reaching influence or centrality in the current research landscape, they are well-developed areas of study. Meanwhile, quadrant 4 (bottom right position) which is “basic themes” contains “green economy”, “innovation”, and “China” theme clusters, indicating that these

topics have a high degree of relevance (centrality) but a lower development degree (density). Basic themes are located in the lower right quadrant, which signifies that they are central to the current research landscape and widely recognized but may not be extensively developed in terms of research output.

Table 3: Thematic cluster measurements for keywords

Cluster	Callon Centrality	Callon Density	Rank Centrality	Rank Density	Cluster Frequency
Sustainable Development	8.389	30.235	1	2	2204
green economy	9.950	22.477	2	1	4758

3.8. Co-occurrence of Keywords

Figure 13 presents a visual representation of the distribution of keywords within a particular research field, focusing on the green economy, sustainability, and related themes. The network map showcases how various concepts are interconnected, helping to identify dominant topics and emerging areas for further investigation. In this analysis, keywords are represented by nodes, the big circle is for the keywords often used in the literature, whereas the smaller nodes are for the less used words. In this visualization, a density-based clustering approach combines keywords on the basis of their co-occurrence in documents 775 and in total of 3997 keywords. From these documents, 199 keywords were included in the network, thus being used together collectively by people at least ten times. Unlike the rest of the terms, the core terms ‘green economy’, ‘sustainability’, ‘sustainable development’, and ‘green innovations’ are shown with large nodes implying their core and frequent usage in the field. These phrases are closely related, implying that studies of the green economy, combine aspects concerning the practice and innovation of sustainability in architecture. However, smaller nodes located far away from the core such as carbon emission control and the ecological footprint presented on the degree of the field in a less prominent way, are on the rise but are not yet mature enough to spend considerable time or resources on research in those areas. The visualization also indicates the globalization of the research, with geographical keywords referring to regions like the European Union, and, South Africa. As it is obvious, this network with concepts provides information on specific areas of research within the discipline of green economy and sustainability and what studies have been conducted.

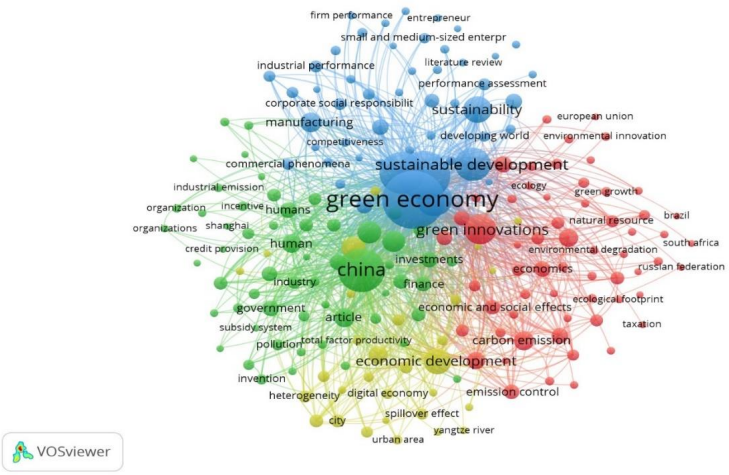

Figure 13: Co-occurrence of Keywords

Table 4: Top Clustering in Green Innovation in Sustainable Entrepreneurship

Cluster	Keywords	Derived Theme
Cluster 1 (red)	alternative energy, Brazil, carbon, carbon dioxide, carbon emission, carbon emissions, climate change, consumption behavior, ecological footprint, ecology, economic analysis, economic and social effects, economic growth, economic growths, economics, emission control, energy, energy efficiency, energy market, energy policy, energy utilization, environmental degradation, environmental innovation, environmental quality, environmental sustainability, environmental tax, environmental technology, European union, foreign direct investment, fossil fuels, global warming, green economies, green energy, green finance, green growth, green growths, green innovations, green technology, gross domestic product, India, industrial economics, institutional framework, natural resource, natural resources, oecd, patents and inventions, policy approach, policy implementation, public policy, regression analysis, renewable energies, renewable energy, resource management, Russian federation, south Africa, taxation, technological development, technological innovation, united states, urbanization	**Environmental and Economic Policy for Sustainable Growth**
Cluster 2 (green)	Article, Asian, Asian people, China, conservation of natural, corporate green innovation, corporates, credit provision, difference-in-difference, differences-in-differences, empirical analysis, energy conservation, environment, environmental impact, environmental legislation, environmental policy, environmental pollution, environmental protection, environmental regulation, environmental regulations, finance, financial management, financial market, financial policy, financial system, financing constraint, fiscal policy, governance approach, government, green credit, green credit policy, green development, green technology innovation, Guangdong, human, humans, incentive, industrial emission, industrial enterprise, industry, invention, inventions, investment, investments, organization, organizations, patent, performance, policy, pollution, pollution control, regulatory framework, research and development, shanghai, state owned enterprise, subsidy system, technology, technology innovation	**Corporate Green Innovation and Financial Mechanisms**
Cluster 3 (blue)	Business, business development, circular economy, commerce, commercial phenomenon, competition, competitiveness, conceptual framework, corporate social response, corporate strategy, decision making, developing countries, developing world, eco-innovation, entrepreneur, environmental economic, environmental manager, environmental performance, Europe, firm performance, firm size, green economy, green innovation, human resource, industrial performance, innovation, innovation performance, knowledge, leadership, least squares method, literature review, manufacturing, market conditions, Pakistan, Perception, performance assessment, policy making, questionnaire survey, regulatory approach, small and medium-sized enterprise, smes, stakeholder, strategic approach, supply chain management, sustainability, sustainable development, sustainable development goal, sustainable entrepreneur, technology adoption, theoretical study	**Eco-Innovation and Corporate Sustainability in Competitive Markets**
Cluster 4 (yellow)	Agglomeration, cities, city, controlled study, digital economy, digital transformation, digitization, economic aspect, economic conditions, economic development, efficiency, efficiency measurement, emissions trading, green innovation efficiency, heterogeneity, human capital, industrial development, industrial structure, industrialization, manufacturing industry, panel data, productivity, regional planning, resource allocation, spatial analysis, spatiotemporal analysis, spillover effect, total factor productivity, urban area, Yangtze river	**Urbanization, Digitalization, and Industrial Transformation**

As shown in Table 4, there are four major clusters: Environmental and Economic Policy for Sustainable Growth (red), Corporate Green Innovation and Financial Mechanisms (green), Eco-Innovation and Corporate Sustainability in Competitive Markets (blue), and Urbanization, Digitalization, and Industrial Transformation (yellow). In the large green innovation in sustainable entrepreneurship cluster, there are five groups of studies:

Environmental and Economic Policy for Sustainable Growth (Cluster 1-Red): This cluster centers on how environmental policies, such as those aimed at reducing carbon emissions and promoting energy efficiency, intersect with economic growth. Key themes include green technologies, renewable energies, and environmental taxation, with a focus on how these areas drive economic policies in various regions including India, Brazil, and the European Union [37-39].

Corporate Green Innovation and Financial Mechanisms (Cluster 2-Green): This cluster explores corporate strategies and financial mechanisms that support green innovation. Themes like green credit, environmental regulations, and technological innovation in industry highlight the role of corporate actions and government policies in advancing environmental goals, particularly in China and other Asian economies [40-44].

Eco-Innovation and Corporate Sustainability in Competitive Markets (Cluster 3-Blue): Focused on the strategies businesses employ to integrate eco-innovation into their operations, this cluster examines competitiveness, supply chain sustainability, and the role of SMEs in sustainable development. It underscores the importance of firm-level innovations and strategic approaches to sustainability in a competitive market environment [45-48].

Urbanization, Digitalization, and Industrial Transformation (Cluster 4-Yellow): This cluster addresses the efficiency of green innovation within the context of urban and industrial development. It emphasizes how digital transformation, spatial and regional planning, and industrial upgrades contribute to sustainable urbanization and improved productivity [49-53].

3.9. Methodological Trends of Selected Papers

Table 5 presents the methodological trends in the "Green Innovation in Sustainable Entrepreneurship" research of selected documents, demonstrating that empirical studies dominate with 403 documents, underscoring a strong preference for data-driven investigations based on real-world observations. Experimental studies come next, with 173 documents, indicating a considerable interest in testing hypotheses within controlled environments. Theoretical studies, with 90 documents, also show notable engagement, reflecting a focus on conceptual frameworks and abstract analysis. Meanwhile, systematic reviews and bibliometric analyses are much less common, with 12 documents each, suggesting a more limited reliance on research synthesis and quantitative analysis of literature. Case studies, represented by just 4 documents, indicate a rare use of detailed examinations of specific instances. Lastly, 81 documents remain uncategorized, pointing to a varied methodological landscape.

Table 5: Methodological trends of selected documents

Approach	Total Number of Documents
Empirical Study	403
Experimental Study	173
Systematic Review	12
Case Study	04
Theoretical Study	90
Bibliometric Analysis	12
Uncategorized	81

4. Discussion

Using bibliometric analysis, the study aims to examine the role of Green Innovation in Sustainable Entrepreneurship. It attempts to give answers to the research questions that were presented earlier in this study. It reveals topics like the most published authors and institutions, the most specialized journals in the field of Green Innovation and Sustainable Entrepreneurship, the trend of the topic from previously published papers, a network analysis of the keywords, a methodological approach, and worldwide documents. These findings highlight the need to immediately identify the research gaps and the research trend for a future research agenda.

Addressing the first research question, Since the field emerged in 2009, the annual publication output in the field has increased steadily from 2009 to 2023, totaling 775 documents. as shown in Figure 3. The 2023, alone accounted for 250 documents which is 32.25% of overall publications. This underscores the escalating scholarly interest in the intersection of green innovation and sustainable entrepreneurship. In response to the second research question, the study identified "Sustainability (Switzerland)" as the most productive journal, with 176 publications. Overall, research was published across 180 sources, indicating a large interest and broad academic engagement with the subject matter within influential journals like "Environmental Science and Pollution Research" and "Resources Policy". This forms the core of the publishing outlets for this area of research, according to Bradford's law as in Figure 4.

For the third research question, the intellectual structure is significantly shaped by author productivity and the application of Lotka's law, which analyses the frequency and contribution of authors within the field. The results indicate that a large portion of contributions is made by a relatively small group of highly productive authors as shown in Figure 5. As shown in Figure 6, the most frequent contributors, such as Wang Y. (21 articles) and Zhang Y. (19 articles), dominate the publications, underscoring the pivotal roles these key researchers play in advancing the discourse on green innovation within sustainable entrepreneurship. Exploring the fourth research question, China is currently the hub of sustainability research with the highest publications and citations and first rank in co-occurrence analysis by country. Even institutions like Jiangsu University and China University of Geosciences with the greatest number of publications are from China. These results suggest that China may play a large role in pushing the frontier from this area of research forward. In conjunction with Pakistan, the United Kingdom, and Italy, those countries rated and placed second, third, and fourth in the total number of publications respectively as represented in Figures 7 and 8.

For the fifth research question, the key concepts include "sustainable development," "green economy," "innovation," and "carbon emission." These concepts are interrelated, with "green economy" and "innovation" being highly relevant but requiring further exploration. Thematic mapping reveals how these concepts are organized and suggests that certain areas, like sustainable development, are well-developed, while others offer potential for deeper investigation. The presence of these niche themes highlights opportunities for researchers to delve deeper into specialized areas that are significant yet less explored. This can lead to innovative contributions that fill gaps in existing literature. These themes often intersect with broader topics, allowing for interdisciplinary approaches that can enrich research outcomes. By concentrating on niche themes, researchers can contribute to a more comprehensive understanding of critical issues in sustainability and environmental impact, paving the way for practical applications and policies. Additionally, Basic themes are crucial for understanding major trends and issues in a given field, making them a focal point for research and policy discussions. By focusing on basic themes, researchers can align their work with broader trends and contribute to significant discussions in sustainability and innovation, potentially influencing policy and practice as depicted in Figure 12. In response of sixth research question, these diverse methodologies indicate a robust and multifaceted approach to studying green innovation, reflecting the complexity and breadth of the field. Each approach contributes uniquely to building a holistic understanding of how green innovation impacts sustainable entrepreneurship, thereby enriching the research landscape.

This research helps fill a gap in the literature on the concept of green innovation in the context of sustainable entrepreneurship as it offers a thorough bibliometric review of development and the state of research in such a domain over the last decade. It recognizes the major trends in research, productive researchers, prominent periodicals, and active organizations, and enriches the body of literature with useful information. At the same time, the study arms itself with the positioning of research gaps in the existing literature to prepare a campaign for future research priorities, bringing attention to the areas that have been understudied and have a high potential for contribution to the theory and practice. Last but not least, the application of advanced tools such as VOSviewer and Biblioshiny illustrates that without much effort, a huge body of publications can be organized and generalized according to bibliometric methods, thus providing practical assistance in carrying out such analyses in the future. The global and institutional mappings serve as useful information for decision-makers and educational institutions for informing policy formulations and enhancing global partnerships. Moreover, the study expands knowledge on the use of technological development in sustainability practices, providing insights into how such creations can

be made to deal with environmental issues. This paper does not only fill the gaps in theoretical frameworks of the existing body of knowledge but also offers actionable implications and networking opportunities, which makes it useful for researchers, policymakers, and entrepreneurs in green innovation and sustainable entrepreneurship.

5. Conclusion and Limitations

In general, sustainability for entrepreneurs has largely come up due to the need for sustainability and sustainable business practices that are aimed at supporting individuals, the environment, and profits. Exhaustion of natural resources, not enough clean water, droughts, and loss of biodiversity are some of the major issues needing sustainable solutions as argued earlier. To be able to achieve such goals as protecting current and future generations' economic welfare, social justice, and environmental concerns; entrepreneurship ought to be sustainable. Ever since the World Commission on Environment and Development (WCED) stated this argument, it means that the present requirements must be met while taking into account the fate of future generations. In conclusion, therefore, a sustained approach would put first long-term growth opportunities balancing economic vitality with ecological integrity together with social fairness.

There are some limitations in our study. One of the limitations is using the Scopus database. For instance, even though it's a comprehensive and reliable database for Social Science research, it will be better to consider using other databases like WoS or Google Scholar. The primary information of the research is thoroughly covered when multiple database sources are used. Secondly, there is another limitation as regards our study being only limited to English publications; future research should incorporate articles published in different languages. In the context of data collection, the title keywords "Green Innovation" OR "Eco-Innovation" OR "Environmental Innovation" OR "Green Economy" are used to focus on the study. Future studies might think about using more keywords to cover a wider range of data collections.

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