Language for Sustainable Development Visualizing the Knowledge Maps by Bibliometric Review

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Abstract

As the linchpin of human society, language not only influences but also delineates the trajectory of sustainable development. This research utilizes 2,527 documents sourced from the Web of Science (2019-2023), employing bibliometric analysis to construct the knowledge maps. It delves into the contemporary status of collaboration, thematic patterns, and emerging trends within this sphere of research, examining aspects such as publication year, authorial, institutional, and national collaborations, keyword clusters, evolution of keywords over time, and keyword prominence. The findings illuminate Lawrence, is the most dominant author and Chinese institutions manifest a notable upper hand in this domain. The United States and China's contributions are particularly significant. From a disciplinary perspective, environmental and natural sciences have shown more interest in this subject compared to social sciences. Keyword cluster analysis reveals that air temperature, sustainable development, motivation, oceans, carbon, impact, and metamorphic rocks are currently the dominant keyword clusters. Furthermore, there is an increasing interest in the intersection of language and sustainable development within social science disciplines in recent years. Moreover, emergent research hotspots are encapsulated in highlighted terms such as education, technology, social media, and teachers. This research fosters a paradigm in language for sustainable development, aptly aligning it with the evolving zeitgeist.

Keywords: *Language industry, Sustainable development, Bibliometric analysis, Knowledge graph, social science, Language for SDGs, education for SDGs.*

1. Introduction

Language is a unique cognitive and communicative ability of human beings，it is also a symbol system and rule constraint system used by human beings to express feelings (Bickerton, 2016). It profoundly affects the progress of science and technology and the development of society (Clayton, 2016; Schiffman, 2012). As far as sustainable development is concerned, language can help humans form a perception and understanding of sustainable development and related concepts (Queiruga-Dios et al., 2020), and then promote the implementation and promotion of sustainable development policies, and ultimately contribute to the realization of sustainable development and its goals (Chankseliani &

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McCowan, 2021). However, the link of language with sustainable development still needs to be estimated.

In an increasingly globalized world, the language for sustainable development has become vital in both the academic and public domains, acting as a bridge that links diverse knowledge spheres and fosters understanding and collaboration (Lourenço et al., 2023). Despite the crucial role language plays, our understanding of its contribution to the sphere of sustainable development remains underexplored.

Over the course of several decades, research in sustainable development has evolved to reveal certain characteristics at the current stage. Firstly, it's increasingly evident that sustainable development is an interdisciplinary and cross-field topic (Liu et al., 2021). Similarly, Mathai et al. (2021) have discussed the implications of the Anthropocene on global sustainability, advocating for further expansion of interdisciplinary research. Sustainable development is a broad field with various subdomains, mainly gathered in climate change, biodiversity conservation, sustainable agriculture, circular economy, sustainable cities, social sustainability, sustainable Energy, sustainable education, health and sustainability, policy and governance for sustainability (Bellezoni et al., 2022; Belmonte-Ureña et al., 2021; Chen et al., 2020; Kumar et al., 2021).

Recently, the role and importance of language in achieving sustainable development and its goals has gained increasing recognition within academia, with a burgeoning number of scholarly contributions in this area (Kamińska et al., 2022). du Plessis and du Plessis (2023) stands as the academic discourse providing a systematic exploration of the interplay between language and sustainable development. However, compared with research in other fields, language for sustainable development is not mature. Hence, the study seeks to illuminate this research gap. It employs a bibliometric analysis approach to investigate the evolution, collaboration networks, thematic clusters, and research trends in the field of language and sustainable development, as reflected in academic publications.

The objectives of this research are to 1) understand the progression of this interdisciplinary field over time, 2) identify key research themes and emerging trends, 3) map the collaboration networks among scholars, institutions, and nations, and 4) generate insights that can stimulate future research and contribute to the discourse on sustainable development.

The expected outcome is a comprehensive knowledge map that reveals the intricate interactions between language and sustainable development, providing a solid foundation for scholars and practitioners in their pursuit of sustainable solutions.

2. Literature Review

Language for sustainable development refers to the role language plays in achieving and promoting sustainable development goals (SDGs). While the concept of sustainable development has since been developed to focus on the three areas of ecological, economic and social sustainability (Jeronen, 2020), the role of language as a key factor in achieving social sustainability has not been fully exploited. This is reflected in two main ways: firstly, the policy itself has not yet highlighted the role and status of language (McEntee-Atalianis & Tonkin, 2023); and secondly, there are limitations in academic inquiry into the issue, and the promotion of sustainable development goals is rare in language studies (Sund & Gericke, 2020; Alizadeh et al, 2021).

Research on sustainability around language can be broadly divided into three categories: those that consider language as an influencing factor, exploring its links to sustainable development and the ways and arenas in which language can contribute to the achievement of sustainable development goals (Caiado et al., 2018); those that use language as a method of data analysis to process policy texts(Alam, 2022; Horne et al., 2020); and those that explore sustainability in specific issues such as foreign language education.

Table 1. The Relationship Between Language and Sustainable Development.

Topics	Contributions	Source
Communication and Education	Language is a crucial tool for disseminating information about sustainable development, promoting awareness, and understanding, and educating people about sustainable practices and lifestyles.	Nogueiro et al. (2022); Glavič (2020).
Policymaking and Implementation	Effective communication, often facilitated by language, is key in crafting and executing sustainable development policies. This includes negotiations at international forums, as well as the implementation of local, national, and global policies.	Bardal et al. (2021).
Cultural Sustainability	Languages, particularly minority and indigenous ones, are integral to cultural diversity and identity. Preserving these languages can be seen as a part of sustainable development, tying into the broader aim of social sustainability.	Yang et al. (2022); Ghahramani et al. (2020).
Inclusivity and Equity	Multilingualism can ensure inclusivity in sustainable development processes, allowing people from diverse linguistic backgrounds to participate and have their voices heard. This aspect ties into the SDG of reducing inequality.	Heugh et al. (2021).
Research and Innovation	Language plays a role in research related to sustainable development. It enables researchers from different disciplines and regions to collaborate, share ideas, and innovate.	Madsen (2020).

In conclusion, language for sustainable development is about leveraging language in ways that help promote and achieve the objectives of sustainable development. This could be through education, policymaking, preserving linguistic diversity, promoting inclusivity, or facilitating research and innovation.

It is now widely accepted that language influences the sustainable development of individuals and societies through its role in education and communication (Alam, 2022; Sund & Gericke, 2020). The role of language in education and communication has two pathways(Ulmer & Wydra, 2022). Firstly, at the individual level, where language is an important tool for individuals to communicate interpersonally and globally, and where language education provides individuals with knowledge and skills that contribute to the effectiveness of communication and thus to sustainable development (Al-Habsi et al., 2021). And secondly, at the societal level, where language provides individuals with knowledge and skills that contribute to the achievement of sustainable development (Al-Habsi et al., 2021). lastly, at the societal level, language education helps to bridge linguistic and cultural gaps between groups, and it contributes to the preservation of culture, the transmission of knowledge and the construction of a common identity, thus contributing to scientific, technological and economic progress and social stability with the aim of achieving sustainable development (Li et al., 2022).

In addition to education and communication, scholars have also explored the ways in which languages play a role from the perspective of governance and policy. Huang and Fang (2021),

Ngo and David (2018) and Vuzo (2018) discuss the relationship between language policy and sustainable development from both the household and national dimensions respectively. Huang and Fang (2021) use the example of multi-dialect China to explore the relationship between household language policy and dialect sustainability from a multilingual perspective. Vuzo (2018) argues that the problem of school dropout among Tanzanian youth has become a major constraint to the achievement of sustainable development goals in the country, due to the current language of education in schools, and suggests that language policies should be developed from a language policy perspective to suit the national context.

Smith et al. (2021) experimented with the integration of computer linguistics and sustainable development. The study argues that existing research on SDGs is strongly limited by its reliance on manual coding and scholars' qualitative determinations, while natural language processing enables the description and quantification of complex networks of SDGs with computer technology, breaking through the subjectivity of existing research methods. The study found strong discursive divergences between environmental goals and all other SDGs, as well as unexpected interdependencies between SDGs in different domains.

The field of foreign language education is almost the main camp of sustainability exploration in the language industry. Han et al. (2021) investigated the engagement, satisfaction, and self-efficacy of university English as a foreign language (EFL) learner in an online learning environment during the COVID-19 pandemic to explore its sustainability. The findings of this study have important implications for the creation of sustainable online learning environments and the promotion of sustainable development among EFL learners. Kwee (2021) incorporates the goal of sustainable development into English classroom teaching. Kwee's study is based on social cognitive career theory and aims to identify important factors that influence English teachers' motivation to incorporate the UN Sustainable Development Goals into their teaching. The findings suggest that teachers' personal beliefs, achievement of teaching goals and supportive school management ca n positively influence their self-efficacy and increase their motivation to integrate the SDGs into English language teaching. Ge et al. (2023) conducted a SWOT analysis to discuss the current situation of foreign language education in China in relation to sustainable development, using German language education as an example. The study found four trends in the sustainable development of foreign language education in China: promoting sustainable multilingual education, developing sustainable citizens, integrating cultural values for sustainable development, and digitalization for sustainable foreign language education.

Therefore, most of the existing review studies have been conducted in the context of education (Babaci-Wilhite et al., 2012), In the scholarly discourse surrounding sustainable development, there remains a paucity of comprehensive reviews and syntheses of pertinent research emanating from diverse fields. With respect to methodological approaches, the preponderance of research is characterized by an emphasis on case studies and theoretical explorations (Babaci-Wilhite et al., 2012; Obiegbu, 2015; Zygmunt, 2016), and there is a lack of quantitative research based on scientific mapping.

3. Research Method

Bibliometric analysis is a research method that quantitatively analyses scientific and scholarly publications and focuses on patterns in citations and other literature data (Nicolaisen, 2009) which has been widely used in review-related research, abandoning the limitations of traditional

bibliometric methods that rely on manual analysis by researchers. In addition, the visualization technique has become a tool for bibliometric research due to its intuitive, easy-to-understand and diverse nature to help researchers gain insight into the dynamics of a field of study, such as the relationships between authors, institutions and research subjects. It can also help the academic community to identify research gaps and research opportunities, as well as to assess the impact of research and scholarly output.

Citespace, based on an embedded algorithm, can visualize the knowledge structure, important research institutions and researchers, and hotspots of the literature search results at a given time (Luo & Jiang, 2023). Therefore, this study will use Citespace as a research tool to first sort out author, institution, and regional collaborations, and then focus on keyword analysis, such as high frequency words, keyword clustering and keyword highlighting.

This study used the core database of Web of Science (WoS) as a sample source and searched the literature between 2019 and 2023，tab1e 1 has shown a consistent growth in the volume of literature over the past years. Starting with 578 publications in 2019, there has been a steady increase, reaching a peak of 648 publications in 2021. The trend continued with a minor decrease to 639 articles in 2022. However, it is important to note that only 40 publications have been documented in the year 2023 thus far, indicating that the data for this year is likely incomplete at the time of this analysis. These figures underline the growing academic interest and research efforts in the interdisciplinary study of language and sustainable development.

The specific search criteria are as follows: "article type" for "journal article"; "subject" for "language, charcoal" "Language, Sustainable Development Goals", "Language, Sustainable Development", "Language, Sustainability", "Language " is "English". The specific formulae are:

(((TS=(language)) AND TS=(Carbon)) AND LA=(English)) AND DT=(Article)

(((TS=(language)) AND TS=(SDG)) AND LA=(English)) AND DT=(Article)

(((TS=(language)) AND TS=(sustainable development)) AND LA=(English)) AND DT=(Article)

(((TS=(language)) AND TS=(sustainability)) AND LA=(English)) AND DT=(Article)

Based on the above conditions, a total of 2830 search results were obtained. To enhance the relevance of the literature, 3 duplicates and 303 discards were found through manual screening and other means, resulting in a final valid literature of 2527.

Table 2. Basic information of literature data

Total Records Found: 2830

2830   Article

Total Unique Records (Article): 2527

Duplicates: 3

Discarded: 303

Years: 5

2019   578

2020   622

2021   648

2022   639

2023   40

Total unique records exported: 2527.

WOS Records found: 2830.

WOS Records retained: 2527.

The shift from individual to group as the basic unit of scientific research suggests that collaboration has become an important form of scientific research (Su et al., 2019). In the scient metric study, the analysis of collaborative networks presented mainly the collaborative relationships between the results of researchers from different institutions, countries, and regions in the selected literature. In Citespace, keyword co-occurrence analysis measures the relevance of keywords by identifying keywords that appear in the same document. The network generated by keyword co-occurrence visually reveals the similarities and associations between keywords in the literature (Chen, 2006). At the same time, the software helps researchers to explore research hotspots in the literature and predict research trends through statistics and calculations of keyword citation frequency and intensity. In addition, Citespace extracts tags from the titles, indexes or headings of the cited literature to form clusters based on similarities or commonalities among the complex literature, with a high degree of similarity within the same cluster and a high degree of variation between clusters (Börner et al., 2005).

4. Results

Katz and Martin (1997) define scientific research collaboration as researchers working together to achieve a common goal of generating new scientific knowledge. Collaborative scientific research is now an important avenue for interdisciplinary research, laying the foundation for overcoming research challenges, pushing research boundaries, etc. In this study, Citespace-based relationship networks were generated to reflect collaborations between scholars, between research institutions, between countries or regions, and between journals.

4.1 Author Collaboration Knowledge Map

Author collaboration networks are intended to be used to analyze joint research within a field (Perianes-Rodríguez et al., 2010; Yang et al., 2016). Figure 1 portrays there are a total of 246 nodes with 337 connected lines, which means that there are 246 highly productive authors in the field and 337 collaborations have been formed between authors. The size of the nodes represents the number of publications, with the larger the node, the higher the number of publications, and the thickness of the links between the nodes reflects the strength of the author collaboration, with the thicker the link the stronger the collaboration, indicates that researchers in this field are more active, and the top 9 highly cited authors are shown in Table 3. In addition, except for Gusztav Belteki, Hailong Wang and Thomnas Hickler, who have formed a strong network of collaborative relationships among their

authors, the other authors have weak or even no collaborative relationships with each other. In general, there is an initial range of relatively stable collaborative relationships in this field, but they are limited to a few authors.

Figure 1. Author Co-Operation.

Tabel 3 The Ranking of Highly Cited Authors.

Counts	Year	Authors
9	2021	Lawrence Jun Zhang
6	2020	Jing Wang
5	2020	Christian Frankenberg
4	2019	Ellen R M Druffel
4	2019	Gusztav Belteki
4	2019	Hailong Wang
4	2019	Hanqin Tian
4	2022	Rashid Mehmood
3	2022	A G Perri

Table 3 appears to provide information on the frequency of publications by certain authors in specific years. It lists three main columns: Counts, Year, and Authors. The "Counts" column represents the number of papers or articles the author has published each year. The "Year" column specifies the year in which the papers were published. The "Authors" column lists the names of the authors who published the papers. To illustrate with an example, "Lawrence Jun Zhang" published 9 articles in the year 2021. Similarly, "Jing Wang" published 6 articles in 2020, and "Christian Frankenberg" had 5 publications in the same year. From table 2, one could infer the productivity of these authors in their respective fields over the years listed. It could be used to track the research output of a particular author or to understand patterns of productivity across different years.

4.2 Institutional Collaboration Knowledge Map

Figure 2 uncovers the institutional collaboration network, from which for frequencies greater than or equal to 15, a total of 1,370 links were generated between 308 nodes, with a link density of 0.0294. The number of nodes, the number of links, and the link density indicate that many research institutions are committed to the field, and that close and complex collaborative relationships have been formed between institutions. Specifically, the top nine institutions with the highest number of citations are shown in Table 4. Among the nine highly cited institutions mentioned above, Chinese Acad Sci has nearly double the number of citations than the second place Univ Colorado, which indicates that research institutions worldwide have established collaborative relationships with Chinese Acad Sci and that Chinese Acad Sci has a strong influence in this field.
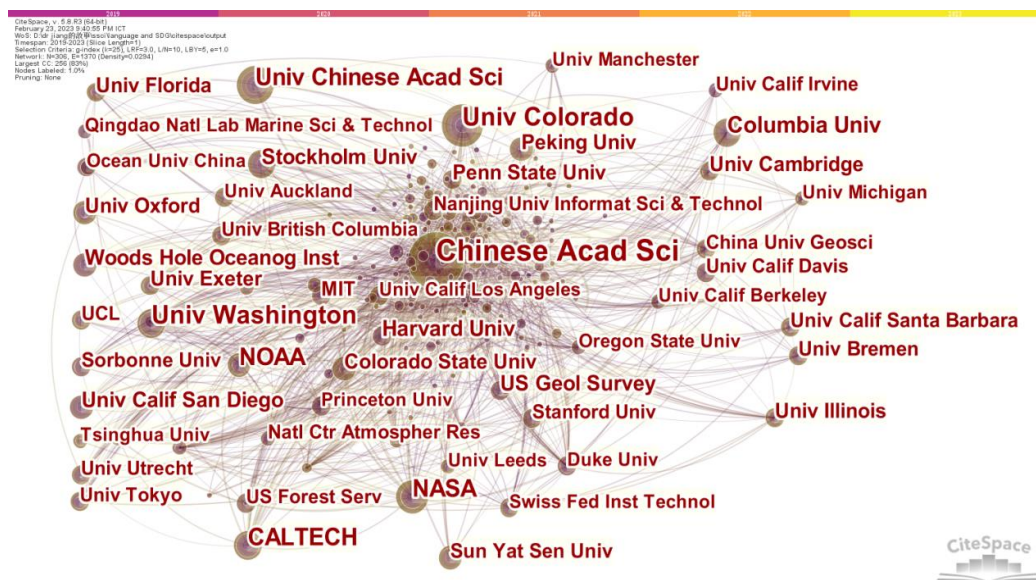

Figure 2 knowledge Map of Institution Co-Operation.

Tabel 4 The Ranking of Highly Cited Institutions.

Counts	Year	institutions
100	2019	Chinese Acad Sci
51	2019	Univ Colorado
45	2019	Univ Washington
40	2019	NASA
40	2019	Univ Chinese Acad Sci
38	2019	CALTECH
37	2019	NOAA
30	2019	Columbia Univ
28	2019	Harvard Univ
27	2019	Univ Calif San Diego

Table 4 outlines the frequency of publications tied to various institutions in a specific year. The columns "Counts", "Year", and "Institutions" respectively indicate the number of publications, the publication year, and the institutions associated with those publications. The Chinese Academy of Sciences (Chinese Acad Sci) is recorded as having 100 publications

in 2019. Similarly, the University of Colorado (Univ Colorado) had 51 publications, and the University of Washington (Univ Washington) had 45 publications in the same year. This information can be valuable for assessing the research output of different institutions in a particular year and understanding their contribution to the study of language for sustainable development.

4.3 Country/Regional Cooperation Knowledge Map

Figure 3 shows the national/regional cooperation network, which, at a frequency greater than or equal to 15, generates a total of 1,424 links between 448 nodes with a density of 0.0142. Sustainable development as a global issue is relevant to all countries, so there is a multilateral, close and diverse cooperation between countries and regions of the world as shown in the figure. The nine countries with the highest number of citations are shown in Table 5. It is clear that the United States has established the most extensive cooperation with countries/regions around the world in this area, but it is important to note that of the nine countries mentioned above, only China is a developing country and the others are developed countries. Scientific research is based on human, material and financial resources, and it is logical that most developing countries, especially those in the southern hemisphere, are limited by objective conditions to form relatively weak collaborations in this field.

Figure2. Knowledge Map of Co-Operation of Nations/Regions.

Table 5. The ranking of highly cited nations/regions.

Counts	Year	Countries
783	2019	USA
377	2019	PEOPLES R CHINA.
223	2019	ENGLAND.
172	2019	GERMANY.
132	2019	AUSTRALIA.
129	2019	CANADA.
91	2019	SPAIN.
88	2019	FRANCE.
79	2019	NETHERLANDS.
71	2019	SWEDEN.

Table 5 presents the volume of publications associated with different countries in a specific year. The "Counts", "Year", and "Countries" columns represent the number of publications, the publication year, and the corresponding countries, respectively. In the year 2019, the United States (USA) was associated with 783 publications, while the People's Republic of China (PEOPLES R CHINA) had 377 publications. England was tied to 223 publications, and Germany had 172 publications in the same year. These data points can be useful for evaluating the research output by country in a particular year, shedding light on the global landscape of research in language for sustainable development.

4.4 Knowledge Map of Disciplinary Collaboration Analysis

Disciplinary collaboration analysis in Citespace identifies relationships between journals based on their co-occurrence in the same documentary record. It can help researchers understand the structure of a research field and the relationships between different journals publishing in that field, as well as help researchers identify the most influential journals in a particular research field and the relationships between different research communities (Chen, 2006).

After setting the citation frequency to greater than or equal to 50, a total of 375 nodes were obtained, with a total of 1583 links between nodes, the details of which are shown in Figure 4. The 10 journals with the highest number of citations in the cited disciplines and their rankings are shown in Table 6. Combining the disciplinary cooperation network diagram with the ranking table of highly cited journals shows that: one, a large number of disciplines pay more attention to the issue, and journals from different disciplines and different fields have published relevant research results; there is extensive and deep close cooperation between disciplines, but there is not yet a closed-loop cooperation relationship; Environmental Sciences& Ecology has the largest number of nodes with the highest number of citations Therefore, it is the most influential; among all the highly cited journals, there is only one highly cited journal in the social science category, Education& Educational Research.
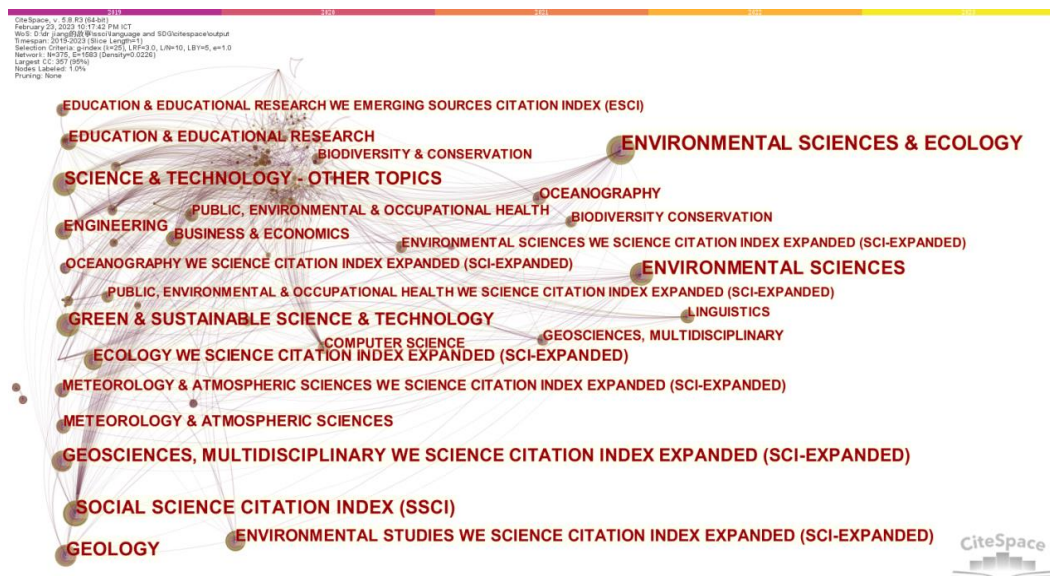

Figure 3. Knowledge Map of Co-Operation of Journals.

Table 6. The Ranking of Highly Cited Journals.

Counts	Year	Category
822	2019	Environmental Sciences & Ecology
492	2019	Environmental Sciences
475	2019	Social Science Citation Index (Ssci)
450	2019	Geology
367	2019	Geosciences, Multidisciplinary We Science Citation Index Expanded (Sci-Expanded)
364	2019	Science & Technology - Other Topics
305	2019	Green & Sustainable Science & Technology
243	2019	Environmental Studies We Science Citation Index Expanded (Sci-Expanded)
157	2019	Ecology We Science Citation Index Expanded (Sci-Expanded)
148	2019	Education & Educational Research

The table 6 presents the distribution of publications in the field of language for sustainable development across different academic categories or disciplines for the year 2019. The category of "Environmental Sciences & Ecology" had the highest number of publications with a count of 822 in 2019. This is followed by "Environmental Sciences" with 492 publications and "Social Science Citation Index (SSCI)" with 475 publications. Other categories like "Geology" and "Geosciences, Multidisciplinary WE Science Citation Index Expanded (SCI-Expanded)" had 450 and 367 publications, respectively. The information can be useful for understanding the distribution of research across various academic disciplines, showing which fields are engaging most extensively with the study of language for sustainable development.

4.5 Keyword Clustering Analysis

Keyword analysis refers to the use of Citespace software to examine and explore keywords in a body of literature with a view to helping researchers understand the landscape of the research field and identify important concepts, themes, and relationships in the literature, while also helping researchers understand the structure, trends and dynamics of knowledge in a given field. This study compares existing research in terms of keyword clustering, time series, and emergent terms.

Cite-space uses a clustering algorithm to group related keywords based on their co-occurrence patterns, which helps to identify clusters of keywords representing specific research topics or subfields (Yang et al., 2016). In this study, seven clusters were generated based on the original parameter settings of the software, and Table 7 shows the specific information of each cluster, with only the top five keywords retained due to the large number of keywords included in each cluster. The seven clusters are #0 temperature, #1 sustainable development, #2 motivation, #3 ocean, #4 black carbon, #5 impact and #6 metamorphic petrology. metamorphic petrology.)

Table 7. A General View of Keyword-Clusters and Top 5 Keywords.

Count	Size	Year	Keywords (top5)
0	86	2019	climate; model; dynamics; productivity; land use
1	86	2020	sustainable development; social marketing; nomological network; macro approach; critical thinking
2	83	2020	sustainable development; multilingual education; dominant language constellations; multilingual literacies; form-meaning interface
3	80	2019	ocean; carbon; variability; climate; observations
4	39	2019	black carbon; boundary layer; pm2.5; text analysis; greenhouse gases
5	6	2021	impact; transport; black carbon; height; forest
6	4	2021	computed tomography; geochemistry; emplacement; serpentinite; earthquake

Table 7 provides data on the top five keywords used in various publications on language for sustainable development, for given years. The "Count", "Size", "Year", and "Keywords (top5)" columns denote the index of the keyword cluster, the number of articles using those keywords, the year of publication, and the specific keywords, respectively.

The most frequent keyword cluster in 2019 (with an index of 0 and appearing in 86 articles) included 'climate', 'model', 'dynamics', 'productivity', and 'land use'. Similarly, in 2020, two keyword clusters (indices 1 and 2) with the same article count of 86 had keywords 'sustainable development', 'social marketing', 'nomological network', 'macro approach', 'critical thinking', and 'sustainable development', 'multilingual education', 'dominant language constellations', 'multilingual literacies', 'form-meaning interface', respectively. This data can provide insight into the primary topics and trends within the field of language for sustainable development in these specific years.

4.6 Time Series Analysis of Keywords

Time series in Citespace refers to the order in which keywords appear and change in the literature over a certain time frame, and it reflects the evolution and trends of a particular field or research topic over time (Chen, 2006; Yang et al., 2016). In essence, it is keyword clustering plus temporal division.

In the diagram (Fig. 5), seven clusters are aggregated on the right-hand side, with each cluster corresponding to a horizontal line on the left-hand side, and all the keywords on the horizontal line belong to the cluster with the same research theme. As shown in Figure 5, there are significant differences in the number and content of hot topics across the clusters within the same time slice, and there are also differences in the trends across the clusters throughout the time slice from 2019 to 2023. In cluster 1 (#0 sustainable development), for example, climate change, systems, carbon, variability, and management are the keywords in 2019, while in 2020 the number of keywords decreases to three, namely innovation, resources and CS1. The only keyword in 2022 is food, and in 2023 the number of keywords increases to three, namely computing, centre and Asia. It is worth noting, however, that Cluster 4 is named Arctic Ocean, but the keywords for this cluster between 2019 and 2020 are knowledge, education, English, students, and health, respectively.
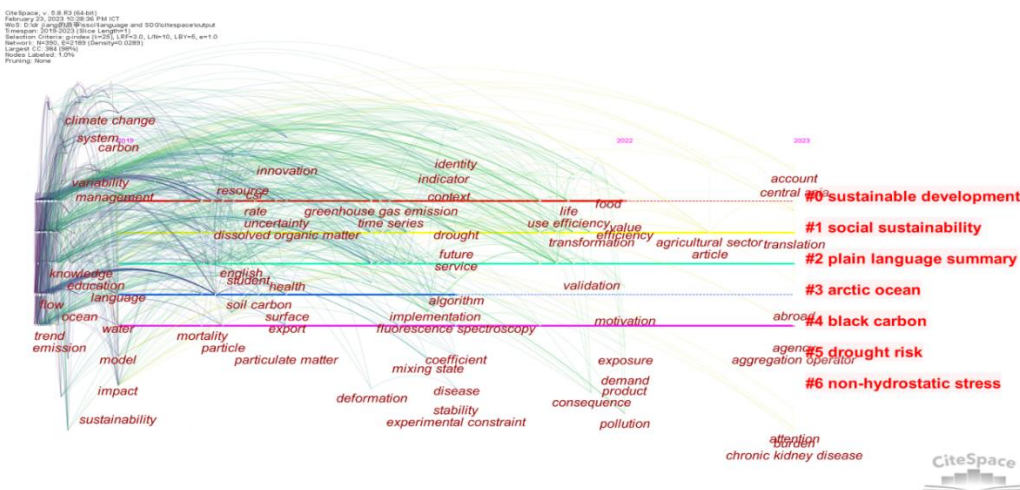

Figure 5 A Timeline Visualization of the Keyword Network.

4.7 Prominent Words and Trend Analysis

Citespace allows specific keywords to be visually highlighted, making them more visible and easier to analyze. Highlighting certain keywords can help researchers focus on the existing research interests of researchers in a particular field as well as future trends (Wei et al., 2022). This section provides a summary of past and current research hotspots, as well as a forecast of future trends.

This table 8 presents the usage trends of specific keywords in the field of language for sustainable development over a time (2019-2023). The "2019 - 2023" column presents the usage trend of each keyword across the years 2019 to 2023, where the density of the symbols signifies the intensity of the keyword usage. More density suggests higher usage. For example, the keyword "phosphorus" started appearing in the literature in 2019, had a strength of 3.22, and was used until 2020. Its usage trend shows that it was more frequently used in 2019 and 2020 and then saw a decrease. In contrast, the keywords "student", "identity", and "context" started gaining traction in 2021 and continued to be prominent until 2023, as suggested by their usage trend. The data helps to understand the focus of the research in the field of language for sustainable development and the shift in emphasis of various keywords over time.

Table 8 illustrates the top 25 keywords in terms of citation intensity between 2019 and 2023 were selected for this study, with differences in intensity for each keyword as well as in the onset and duration of their prominence. As this study includes literature up to March 2023, which is not yet over, keywords appearing between 2019 and 2020 are classified as past, those appearing between 2021 and 2023 are attributed to the present, and those to appear after 2023 are classified as future.

Based on the onset and duration of the prominence, phosphorus, circulation, photosynthesis, oxygen, marine, stable isotope, atmosphere, inorganic carbon, sea, and elevated CO2 have been the hotspots of previous studies. inorganic carbon, sea and elevated CO2 have been the focus of previous research. Uncertainty, student, identity, context, innovation, drought, implementation, higher education, people, technology. people, technology, service, future, Africa, teacher, and social media are the current research hotspots. A comparison of the research subject headings shows a gradual shift in interest from the natural sciences to the humanities and social sciences. In addition, the human element, as the subject of education and policy implementation, has become a hot topic of research. The intensity and duration of the keywords at a given time can broadly reflect the future trends in the field. In view of this, this study selected keywords with an intensity of 3.0 or higher from 2021 to 2023: students, identity, and context. Students as the main subject of educational activities, and therefore higher education and teachers with high prominence associated with them, will also be the key research questions in the field in the future.

Table 8 Keywords with most Recent Citation Burst Since 2019.

Keywords	Year	Strength	Begin	End	2019 - 2023
phosphorus	2019	3.22	2019	2020	
circulation	2019	2.59	2019	2020	
photosynthesis	2019	2.5	2019	2020	
oxygen	2019	2.32	2019	2020	
marine	2019	2.32	2019	2020	
stable isotope	2019	2.15	2019	2020	

Keywords	Year	Strength	Begin	End	2019 - 2023
atmosphere	2019	2.15	2019	2020	
inorganic carbon	2019	2.15	2019	2020	
sea	2019	1.97	2019	2020	
elevated co2	2019	1.97	2019	2020	
uncertainty	2019	2.16	2020	2021	
student	2019	3.44	2021	2023	
identity	2019	3.33	2021	2023	
context	2019	3.11	2021	2023	
innovation	2019	2.77	2021	2023	
drought	2019	2.66	2021	2023	
implementation	2019	2.66	2021	2023	
higher education	2019	2.44	2021	2023	
people	2019	2.29	2021	2023	
technology	2019	2.23	2021	2023	
service	2019	2.22	2021	2023	
future	2019	2.08	2021	2023	
africa	2019	1.99	2021	2023	
teacher	2019	1.99	2021	2023	
social media	2019	1.99	2021	2023	

5. Discussion

5.1 Interpretation and Implications of the Findings

In contemporary scholarly discourse, the role of language has increasingly been recognized as a pivotal component within the realm of sustainable development (Tomalin et al., 2019). This recognition has catalyzed a sustained interest and sparked animated discussions among academics. Conventionally, bibliometric methodologies employed in sustainable development studies have primarily centered around themes such as tourism (Khanra et al., 2021; Niñerola et al., 2019), energy (Arsad et al., 2023; Roslan et al., 2022; Shasha et al., 2020), markets (Ferreira et al., 2021; Figueroa-Rodríguez et al., 2019), and biology (Mougenot & Doussoulin, 2022; Wei et al., 2022).

The integration of language and sustainable research represents a rather expansive topic and offers a multifaceted perspective on the subject matter. As such, this study represents a novel undertaking that employs bibliometric analysis to comprehensively review and interpret the domain of language for sustainable development. By doing so, this research offers valuable insights that can inform and guide the selection of methodologies for future studies in this interdisciplinary field.

Drawing on the systematic review of pertinent literature in the field of sustainable development research from 2019 to 2023, this study provides an analysis and synthesis of the current state of collaborations amongst scholars, institutions, countries, regions, and academic journals. Firstly, the interactions among institutions, countries, and regions are found to be intricate and varied, illustrating that academic entities from diverse countries and regions have established tight-knit and multilateral research collaborations concerning language within sustainable development. However, it's noteworthy that these relationships have yet to evolve into stable, long-term alliances. Secondly, the elaborate network of journal collaborations underscores the multidisciplinary and interdisciplinary lenses through which

scholars undertake language research in the context of sustainable development. This multiplicity of perspectives enhances the depth and breadth of research in this field. Lastly, it becomes apparent that there remains considerable room for bolstering collaboration amongst individual authors. Strengthening such collaborative networks could facilitate the exchange of ideas and insights, potentially catalyzing further advancements in the field of language for sustainable development.

The application of keyword clustering, time-series analysis, and highlighted words in our study elucidates the extensive and fruitful research concerning the role of language in sustainable development.

Primarily, the magnitude of Cluster 3 represents the significant attention devoted to this topic by scholars, thereby underlining its relevance in the academic discourse on sustainable development. Secondly, the keywords associated with this cluster, namely multilingual education, dominant language clusters, multilingual literacies, and form-meaning interface, reflect the research spectrum of scholars. These domains encapsulate elements such as language diversity and language choice, which are integral to a nuanced understanding of language's role in sustainable development. Lastly, it becomes evident that language influences sustainable development at both individual and societal levels through its function in education, communication, and identity formation.

This study enriches the theoretical understanding of the role language plays in sustainable development. By demonstrating the increasing importance of language in diverse sustainable development contexts, it illuminates the need for further incorporation of linguistic aspects into sustainability theories. Additionally, it highlights the multidimensional nature of sustainable development, requiring interdisciplinary perspectives. The prominence of keywords like 'students', 'identity', and 'context' signify the influence of sociolinguistic factors on sustainability, thereby warranting their inclusion in theoretical frameworks. Lastly, the anticipated future research areas signal the evolving nature of this field, suggesting a dynamic approach to sustainability theory development.

5.2 Implication to Practices

This study underscores the practical significance of incorporating language considerations into sustainable development strategies. Recognizing the critical role of language in education, communication, and identity formation can inform policymaking, curriculum design, and community engagement efforts. For instance, acknowledging language diversity and choices can lead to more inclusive and effective communication strategies in sustainability campaigns (Songyu, 2021). Additionally, the highlighted future research areas, like higher education, teachers, and social media, suggest potential avenues for practical application. Educators can be trained to foster sustainability consciousness using multilingual methods, while social media can be leveraged to spread awareness and facilitate discussions on sustainability (Jiang & Wang, 2022; Jiang & Zhao, 2022; Ebrahimzadeh et al, 2022). As such, this study offers valuable insights for practitioners aiming to drive sustainable development initiatives.

This study emphasis the need for increased collaboration among researchers in the field of language and sustainable development. Despite noteworthy contributions from institutions in the U.S. and China, there's a discernible gap in shared authorship. Organizations should encourage collaborative efforts, fostering cross-disciplinary research that bridges the divide between environmental and social sciences. This could yield a more comprehensive

understanding of sustainable development, boosting the impact and applicability of research outcomes. The under-representation of social sciences suggests a potential area for growth, prompting a broader inclusion of socio-linguistic perspectives in sustainable development studies.

Building upon the practical implications of sustainable development research, the emergent themes and their evolution over time provides valuable insights. While there was a focus on physical factors such as phosphorus, oxygen, and inorganic carbon in the early years (2019-2020), there was a shift towards human-centred issues such as student identity, higher education, and teachers in the latter years (2021-2023).

Practically, this shift signifies an increased emphasis on the role of education in sustainable development. Policymakers should consider creating educational policies that integrate sustainable development principles in curriculums, helping students develop a more profound understanding of these issues.

The emergence of "innovation", "technology", and "implementation" as keywords also suggests that leveraging technology for innovative solutions is paramount. As such, practitioners should consider fostering an environment that encourages the development and implementation of innovative technological solutions for sustainable development.

The prominence of "social media" as a keyword in the latter years implies a growing recognition of its role in spreading awareness and promoting sustainable practices. Therefore, sustainable development practitioners should leverage these platforms effectively to reach wider audiences.

Finally, the emergence of "drought" and "Africa" indicates an increasing awareness of specific challenges faced by certain regions. It underscores the need for context-specific strategies that address unique local issues, further underscoring the need for adaptable and flexible policies and practices in sustainable development.

5.3 Limitations and Future Study

While this study utilizes the Web of Science (WoS) database, only English academic papers, to ensure research sample quality, it inherently restricts the sample size. Future studies should consider diversifying data sources beyond WoS to broaden research samples and enrich the understanding of language in sustainable development. Comparing analysis outcomes across various databases can yield more nuanced and valuable insights. This study's reliance on a single tool, Citespace, although effective in literature analysis visualization, also poses a limitation due to the tool's inherent constraints. Complementing Citespace with other analytical software could provide a more comprehensive view and cater to a wider range of research needs.

Conclusion

In conclusion, the field of language for sustainable development is evidently growing and diversifying. The study has underscored the value of cooperation among authors, institutions, and countries in bolstering research output and progress. Our analysis of keyword trends signals the evolution of the research focus, underlining the multifaceted nature of sustainable development that encompasses environmental, social, and educational domains.

It is incumbent upon developed countries and leading research institutions to foster an environment of collaboration and support, particularly involving researchers from developing countries. The study inspires more researchers to participate in this field and pushes for a multi-disciplinary approach, encompassing aspects from environmental sciences to social sciences, to gain a holistic understanding of language's role in sustainable development.

Future research endeavors need to be cognizant of the changing research trends and adapt accordingly. By prioritizing education, technology, and cooperation, we can effectively catalyze transformative research that is attuned to the changing needs of sustainable development.

Author Contributions

Conceptualization (S.J., K.X, and H.L.); Methodology (S.J. E.O and H.L.); Analysis (S.J. K.X,); Software (E.O, S.J.); Writing, reviewing (S.J., H.L, M.R); Editing (S.J., H.L, M.R); Visualization (S.J., H.L, M.R).

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Conflicts of Interest

The authors declare no conflict of interest.

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