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Review

Knowledge Mapping of Cultural Ecosystem Services Applied on Blue-Green Infrastructure—A Scientometric Review with CiteSpace

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Abstract: Urban blue-green infrastructure (BGI) not only serves an ecological purpose but also contributes to the physical and psychological well-being of residents by providing cultural ecosystem services (CES), which are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. CES is a rising BGI research and management subject, with a growing number of papers in recent years. To identify and differentiate the latest research on the development of features based on cultural ecosystem services within blue-green infrastructure, we employed CiteSpace bibliometric methodologies to analyze pertinent papers for focusing on the developmental processes and key research areas. The publishing trend, research clusters, highly cited literature, research history, research frontiers and hot areas, and high-frequency and emerging keywords were studied and assessed after reviewing 14,344 relevant papers by CiteSpace software 6.3.1 from Web of Science. The standard domains concerned, according to the keyword visualization and high-value references, are implemented cultural ecosystem services assessment combined with natural-based solutions in green spaces, urban regions, residential areas, and sustainable development. In conclusion, the following recommendations are made: (1) When urban decision-makers incorporate the perspective of cultural ecosystem services into the strategic formulation of BGI, a broader spectrum of urban BGI types should be taken into account; (2) all categories of CES should be considered; (3) research on the application of cultural ecosystem services in urban blue-green infrastructure should be more effectively and flexibly integrated into urban governance; and (4) CES should be strategically employed to improve the physical health and psychological well-being of urban residents.

Keywords: cultural ecosystem services; ecosystem services; blue-green infrastructure; knowledge graph; information visualization; CiteSpace

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1. Introduction

Cities are complex systems with multiple dimensions, including social, economic, ecological, and infrastructure issues. They function as large-scale hubs on which a sizable section of the global population depends for subsistence and livelihood. The quality of the urban environment has a direct impact on the physical and mental well-being of city dwellers, which is inextricably linked to overall human well-being. Green and blue areas in urban and rural settings are frequently referred to as urban green and blue infrastructures (BGI). In many countries, BGI is widely considered as an instrument for sustaining and improving ecosystem services and urban ecosystem management policies [1,2]. Ecological services (ES) are ecological contributions that benefit civilization as a result of interactions between biotic and abiotic processes; the Millennium Ecosystem Assessment [3] defines ES as the advantages that people receive from ecosystems [3]. These advantages are widely classified as provisioning (e.g., food, water), regulating (e.g., pollination regulation, water regulation), supporting (e.g., biomass production, soil formation), and cultural services (CES). Among these ES, CES are defined as "the intangible advantages that individuals derive from ecosystems, including spiritual enrichment, cognitive growth, contemplation, recreation, and aesthetic encounters". [4] Therefore, cultural ecosystem services emerge from the dynamic interplay between humanity and the natural world, assessing the intangible advantages of the surroundings predominantly through the lenses of psychology and spirituality. In our study, we focus on the cultural ecosystem services provided by urban and other human-transformed environments. We consider these environments as cultural ecosystems that offer diverse values and benefits to people, which is the primary focus of our study. Within these areas, green and blue infrastructure provides a variety of benefits and services.

The CES generated by BGI to improve the physical and mental health of urban residents are increasingly being examined by academics. [5,6]. For example, urban green infrastructure (UGI) provides opportunities for inhabitants to interact with nature and spaces for recreation, social interaction, education, etc. [6] The BGI concept integrates CES considerations into the core of broader environmental conservation decision-making and investing and planning, among others. As an illustration, cultural ecosystem services have the potential to unite humans with their immediate surroundings to facilitate landscape design [7]. The significance and potential of cultural ecosystem services utilized in BGI management and produced by BGI in environmental strategies warrant further investigation. With established categorization systems and evaluation criteria, CES has developed into a relatively mature field, enabling the quantification of BGI's specific contributions to the physical and mental health of urban residents. Thus, an increasing number of publications have linked the cultural ecosystem services assessment framework to landscape management and BGI planning research in response to the expanding interest in BGI. [8,9] For example, in several European cities, public participatory mapping and integrated value mapping along with surveys and social media for public perceived CES assessment were utilized in urban BGI planning and administration [10,11]. For urban green infrastructure, bule infrastructure, and coastal management, an experts-based matrix and proxy data approach for cultural ecosystem services supply assessment were also contributed [12,13]. These diverse cases demonstrate that BGI-derived cultural ecosystem services knowledge has the capacity to significantly aid BGI policy formulation and planning. There are several review studies focused on the applied cultural ecosystem services in urban blue-green infrastructure studies. Cheng et al. [8] conducted a review of CES in green infrastructure cases by analyzing more than 67 empirical case studies to determine the geographic distribution of current research, the types of green infrastructure that provide cultural ecosystem services, and the challenges and future directions of CES and urban green infrastructure research. Additionally, there are review studies that concentrate on European or North America countries [14–16]. These studies emphasize the significance of the varied CES offered by different BGIs and the necessity of establishing connections between different types of green infrastructure and the associated practices and cultural ecosystem services benefits. Significantly, the extant literature review investigations concerning the application of cultural ecosystem services in urban blue-green infrastructure have encountered obstacles such as restricted availability of research samples and published data sources, disparities in research across different disciplines, and geographical representation imbalances. Similar to the majority of CES research conducted in Europe and North America, the global distribution of CES review studies is unequal, and little is known about the application of cultural ecosystem services in urban blue-green infrastructure management in developing countries [17]. It is necessary for literature reviews that investigate the implementation of cultural ecosystem services in urban blue-green infrastructure in developing nations to account for this geographical inequality. In addition, the vast majority of cultural ecosystem service evaluations of BGI concern non-urban ecosystems, including forests and oceans [17,18]. Research on cultural ecosystem services is less extensive in urban systems compared to non-urban ecosystems [19]. As a result, research into the application of cultural ecosystem services in urban BGIs, particularly small-scale BGI, has been exceedingly scarce. Given the significant potential and critical nature of cultural ecosystem services in environmental strategies provided by BGI, it is urgent to organize and assess the application of cultural ecosystem services in all scales and categories of BGI using extensive case studies.

Additionally, previous literature reviews have relied mainly on manual reading and collation, which can be a time-consuming procedure [20,21]. Manual reviews are also extremely dependent on the reviewer's subjective assessment, making them difficult to quantify and analyze. Furthermore, simple written summaries may not adequately convey the topic of the research to readers. Bibliometric analyses for literature reviews have yet to be generally embraced in the domain of CES application in BGI [22]. By transforming paper content into data and indicators, these analyses have the ability to rapidly handle massive amounts of literature data, significantly cut review durations, and improve quantification and evaluation. Furthermore, bibliometric analysis software representations explain linkages across literature, allowing readers to quickly grasp the review's substance [23].

As a result, this research offers a comprehensive compilation of the present status of cultural ecosystem services implementation in BGI. The main aim of our research is to delineate the application and research status of cultural ecosystem services (CES) in urban blue-green infrastructure (BGI), elucidate the current research status and its deficiencies, and investigate prospective research directions, thereby offering recommendations for future scholars. The research utilizes bibliometric analysis based on 14,344 relevant papers from Web of Science, which is enabled by CiteSpace, to visually represent the results. It begins with a summary of the most recent research areas, hotspots, and developments in the application of cultural ecosystem services in urban blue-green infrastructure. Additionally, it facilitates the identification of correlations among interconnected research subjects, providing theoretical underpinnings for other scholars and enabling the investigation of novel research pathways and collaborative undertakings. Finally, we discuss future research directions pertaining to the applicability of cultural ecosystem services in urban blue-green infrastructure.

2. Materials and Methods

In this paper, an in-depth review of the current state of literature regarding the application of CES in the context of urban BGI is presented. Previous studies addressed that the MEA in 2005 has been a milestone in ecosystem service research [4–6]. The MEA highlighted CES as an effective means of assessing the impact of ecosystem degradation on human well-being, significantly catalyzing research in the cultural ecosystem services domain. Therefore, we selected 2005 as the starting point for our analysis of paper publications in this field. Data from the primary database of the Web of Science (WOS) platform, encompassing the time period from 2005 to 2022, form the basis of this study.

This study endeavors to furnish readers with a methodical comprehension of co-citation patterns, key clusters, keywords, and the progression of knowledge pertaining to cultural ecosystem service applications in BGI through the utilization of CiteSpace. It accomplishes this by extracting insights from the pertinent literature. Furthermore, this paper provides a concise analysis of extensively referenced literature in this domain, encapsulating the present state of the cultural ecosystem services application and trends in its development within BGI.

The research incorporates the subsequent fundamental elements:

(1) A literature review spanning from 2005 to September 2022 was conducted by employing CiteSpace's literature co-citation analysis, cluster analysis, and keyword co-occurrence analysis. We were able to establish a comprehensive knowledge base and identify knowledge domains regarding the application of cultural ecosystem services in urban blue-green infrastructure as a result of this analysis.

(2) By identifying citation surges, we identified patterns of knowledge evolution in CES applications within BGI.

(3) A knowledge map was developed for the application of cultural ecosystem services in urban blue-green infrastructure, utilizing a knowledge base comprised of keywords

pertinent to the research topic, domains of knowledge associated with fundamental research areas, and knowledge evolution as indicated by citation spurts. This knowledge map reflects the research hotspots and evolutionary process of the application of cultural ecosystem services in urban blue-green infrastructure studies.

2.1. Data Collection

We chose Web of Science (WOS) as the data collection platform for this paper. The literature included in the WOS contains diverse information such as author names, titles, abstracts, keywords, references, publication years, source types, issue numbers, volume numbers, and DOIs [24]. This encompasses all the bibliographic information necessary for our paper's data analysis.

Our first step in identifying relevant studies was to determine a comprehensive set of search words. A fuzzy search was conducted using a combination of three search keywords: "green and blue spaces planning", "blue and green infrastructure", and "cultural ecosystem services" and relevant concepts as keywords [25], which were selected based on our specific topic and after conducting literature search tests and discussions. The search string was (TS = ("green planning" OR "blue planning" OR "green space" OR "blue space" OR "green and blue space" OR "blue and green space" OR "green and blue space planning" OR "blue and green space planning" OR "green and blue infrastructure" OR "blue and green infrastructure" OR "green infrastructure" OR "blue infrastructure" OR "urban green" OR "urban blue" OR " urban river" OR "urban greenbelt" OR "urban wet land" OR "urban green way" OR "green management" OR "blue management" OR "green and blue space management" AND "cultural ecosystem service" OR "cultural service")). Our study focused on English peer-reviewed publications, including articles and reviews. As MEA in 2005 has been widely regarded as the milestone in ecosystem service research [4–6], we selected 2005 as the starting point for our analysis of paper publications. Data were retrieved on 22 September 2022, and a preliminary search of 17,000 original entries in English language from 2005 to 2022 was conducted. After the removal of duplicates, we obtained 15,726 unique entries. Next, we removed articles from non-academic sources to exclude editorials; this refinement reduced the number of studies to 14,420. After a brief review, we determined that these articles had diverse contents, and some did not explicitly match the main objectives of our study, which focusing on the cases of application of CES (e.g., theory, framework, valuation, and spatial assessment) in BGI planning, management, and strategy making. Further manual interpretation of the literature titles, keywords, and summaries was conducted to remove irrelevant articles [26]. In this process, we excluded all papers that did not explicitly address the content of the application of "cultural ecosystem services in blue-green infrastructure". For example, research articles on CES classification, CES connotation, and CES definition, bird studies based on BGI, and recreational experience assessment of BGI were deleted from our database. After the above screening steps, we finally identified 14,344 bibliographic entries for subsequent data processing. The exported literature records, saved as plain text files, were converted and processed using CiteSpace software 6.3.1. These processed data samples were then analyzed in the text.

2.2. Data Analysis

Bibliometric analysis, which is a robust method for investigating large scientific datasets, is extensively employed and acknowledged. This method incorporates both qualitative and quantitative examination of published publications [27]. This approach utilizes data mining, information processing, and visualization techniques to investigate the social and structural connections between various research components, including authors, institutions, countries, journals, keywords, and topics [28,29]. This method is essential for the precise assessment of the current state and the prediction of future developments in fields of study such as medicine, management, and landscape studies. Despite the substantial quantity of research conducted on the subject, the utilization of cultural ecosystem services theory in the design and management of BGI has been the subject of only a limited number of bibliometric studies. In order to quantitatively evaluate and describe research findings regarding the implementation of cultural ecosystem services in urban blue-green infrastructure studies, our investigation employed bibliometric methodologies. The primary goals were to clarify the current state of research, identify prevailing patterns, emphasize recent advancements, and establish future directions for development [29].

In this research, our analysis topics explore the application of cultural ecosystem services in urban blue-green infrastructure, including exploring its publication trends, research clusters, highly cited literature, research history, research frontier and hot areas, and high-frequency and emerging keywords. We selected the CiteSpace program as the tool for doing bibliometric analysis. In this study, we utilized CiteSpace software to examine the collaboration networks of authors, institutions, countries, and co-citations. Afterwards, we performed cluster analysis, examined highly cited literature, investigated the research development history, analyzed high-frequency keywords, and identified emerging keywords using CiteSpace to visualize and explore research hotspots and trends regarding the application of cultural ecosystem services in urban blue-green infrastructure. Figure 1 provides a comprehensive depiction of the step-by-step procedure.

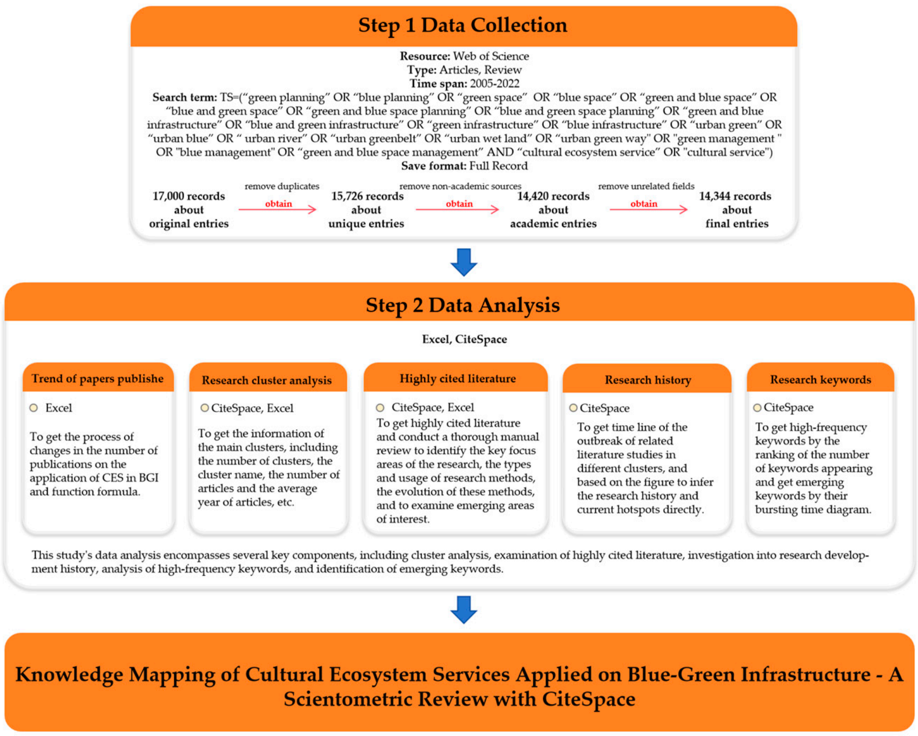

Figure 1. Research framework including data collection and analysis.

CiteSpace Software

CiteSpace is a software program written in Java that attempts to accelerate scientific research by facilitating data mining, data visualization, and information analysis. The system effectively organizes data to aid researchers and analysts in understanding the composition and behavior of scientific papers [30]. CiteSpace's network analysis is based on "nodes" which serve as the fundamental elements, representing different data entities such as keywords, authors, documents, institutions, and geographic regions (countries). The magnitude of nodes is indicative of the citation counts, the frequency of articles or journals, or the influence of the research on the subject being examined. For example, greater citation counts or frequencies are denoted by larger nodes, which signifies a higher level of research significance. Smaller nodes, on the other hand, indicate less frequent occurrences.

The aforementioned nodes are grouped together into "clusters," which represent regions of concentration or significance pertaining to a specific subject matter. Co-citation relationships are represented by the thickness of the connecting lines between nodes; this thickness indicates the degree of co-citation strength. Co-citation strength is proportional to the thickness of the line; thinner lines imply co-citation relationships that are weaker.

Highly cited literature can be identified through literature co-citation analysis. These documents are commonly mentioned and regarded fundamental references within a given field of study. When two documents are regularly mentioned together, it shows that they share a conceptual link. Closely related papers can be identified and classified into clusters based on their interconnection using statistical analysis. Each cluster represents a different area of knowledge, with duplicate clusters representing identical study domains. Interactions between clusters might also demonstrate their importance to one another.

Keyword co-occurrence networks are used to find terms that appear in at least two documents within a given timeframe. High-frequency and core keywords identified as vital hotspots during that time period are an important part of the knowledge base for BGI's CES applications. Currently, the knowledge base and domains in green buildings play a significant role in research efforts. It is also beneficial to use CiteSpace to locate references with high citation bursts. A reference has a ferocious citation burst if it is extensively cited within a specific timeframe, indicating its position as a seminal publication in scientific advancement. Nodes with substantial citation bursts suggest that these articles garnered significant attention during that time period and, to some extent, reflect the discipline's forefront and hotspots.

3. Results

3.1. Trend of Papers Published

After tallying the total number of papers published on the application of cultural ecosystem services in urban blue-green infrastructure over 18 years from 2005 to 2021, as illustrated in Figure 2, several key considerations emerge. It is noteworthy that our data collection period extended until September 2022. However, the data collection for papers in 2022 is incomplete. Consequently, we have omitted the data for the year 2022 from the graph. While the preliminary data for 2022 is temporarily set aside, our analysis indicates a significant exponential growth in the total number of publications on the application of cultural ecosystem services in urban blue-green infrastructure within the specified time frame.

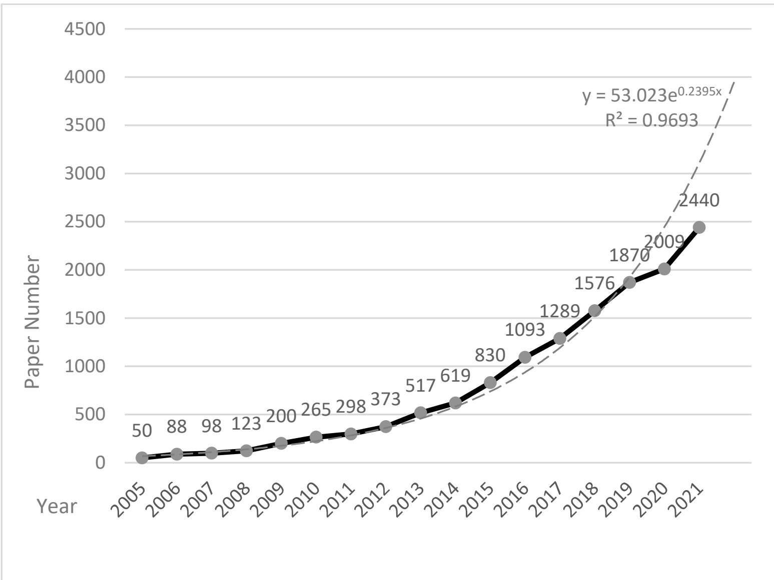

Figure 2. Total number of postings on the use of CES in BGI. The solid line in the figure represents the number of relevant papers published each year, while the dashed line represents the function $y = 53.023e^{0.2395x}$, illustrating the trend in publication volume.

3.2. Research Cluster Analysis

The co-citation analysis conducted by CiteSpace produces a clustering diagram, as illustrated in Figure 3. Within this clustering perspective, the nodes symbolize the objects under examination, with larger nodes indicating a greater frequency. The lines that connect the nodes represent co-citation relationships, and the thickness of these lines corresponds to the strength of the co-citation. An analysis of the co-citation network in the literature study uncovers 12 prominent clusters focused on important nodes, with a specific emphasis on the application of cultural ecosystem services in urban blue-green infrastructure.

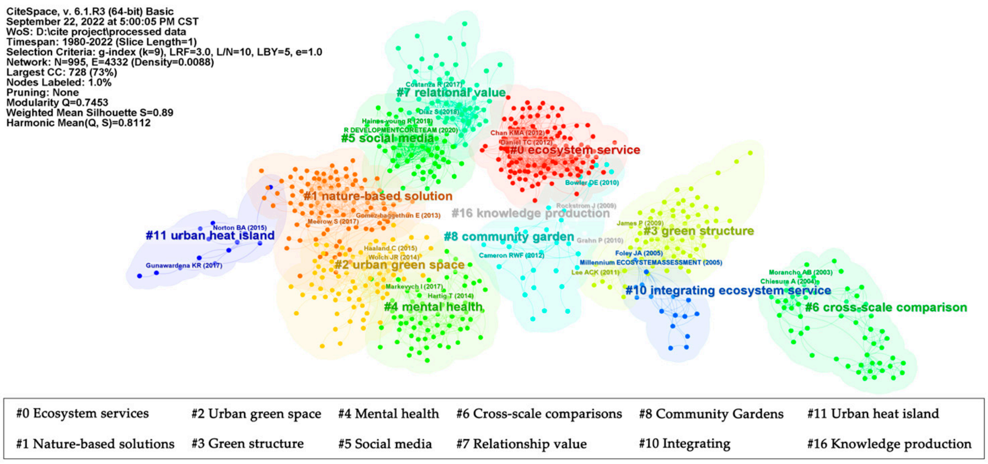

Figure 3. Visualization of co-cited network clustering [3,31–53].

The data in Table 1 were acquired through the utilization of CiteSpace's Cluster Explorer feature. Cluster size refers to the quantity of documents present in each cluster. For instance, Cluster 0 has a size of 130, indicating that there are 130 papers in that particular cluster. Homogeneity quantifies the level of uniformity within a cluster, where higher values indicate a greater degree of resemblance among its members. Cluster 11 demonstrates the highest level of homogeneity, with a value of 0.988, among the 12 clusters. This indicates that it has the greatest resemblance and cohesiveness within the literature. The average year reflects the temporal closeness of cited documents within a cluster to the present, with closer years indicating greater consistency. These clusters symbolize the forefront of contemporary research. Figure 3 and Table 1 demonstrate that the clusters receiving the most research focus are 'Ecosystem Services' and 'Nature-Based Solutions'. Moreover, the cluster labeled 'Nature-Based Solutions' has the most up-to-date research contributions.

Table 1. Research clustering information table.

Serial Number	Cluster Name	Magnitude	Homogeneity	Average Year
0	Ecosystem services	130	0.84	2010
1	Nature-based solutions	106	0.889	2016
2	Urban green space	84	0.806	2015
3	Green structure	80	0.907	2007
4	Mental health	69	0.943	2015
5	Social media	67	0.887	2016
6	Cross-scale comparisons	62	0.962	2002
7	Relationship value	59	0.872	2015
8	Community gardens	31	0.945	2010
10	Integrating	17	0.978	2003
11	Urban heat island	14	0.988	2015
16	Knowledge production	9	0.943	2011

A comprehensive examination of the specifics within these 12 clustering categories identified four core research paths: 1. Value Assessment; 2. Urban Governance; 3. Public Perception and Health; 4. Theoretical Exploration of CES and BGI.

The value assessment component focuses on the classification and evaluation of cultural ecosystem services. CES can currently be categorized into ten broad categories: cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, local distinctiveness, heritage values, and recreation and ecotourism. Recreation and ecotourism receive considerably more attention than the other cultural ecosystem services categories [8]. However, establishing distinct borders among these several cultural ecosystem services categories frequently requires reassessment, resulting in difficult categorizations. Hence, accurately ascertaining the precise value attributed to each service poses challenges [36,54]. Multiple studies emphasize the importance of ecosystem services, particularly the intangible advantages of cultural ecosystem services. Nevertheless, the complete exploration of CES valuation has been infrequent due to methodological difficulties [55,56]. The restricted attention is a result of the inherent intangibility and non-monetary nature of CES, in contrast to other tangible services. Therefore, it is important to thoroughly investigate and comprehend CES assessment. The methods for evaluating CES can be broadly classified into monetary and non-monetary approaches [57,58]. CES facilitates the quantification of cultural ecosystem services by employing an economic approach to value. This is achieved through conducting economic value evaluations, which in turn allows for the tangible and measurable representation of non-material advantages.

Urban governance involves the utilization of CES in urban decision-making processes. This entails providing decision-makers with indicators and recommendations to enhance city governance through the assessment of ecosystem services. Ecosystem services are a rapidly evolving field of study that has a considerable impact on the creation of policies and the promotion of sustainable development [37]. A majority of the population experiences urban surroundings on a daily basis, making urban governance a crucial determinant of urban residents' overall quality of life and living standards. Presently, there is an unequal distribution of green spaces inside urban areas. Statistics on the distribution of green spaces in Europe and the United States indicate that these areas are largely found in rich and predominantly white communities, which worsens environmental disparities. As a reaction, multiple cities in the United States and urban areas in China have implemented tactics to enhance the accessibility of green areas within their urban environments. Expanding urban green spaces may unintentionally increase housing costs, presenting a dilemma that officials in urban government must tackle. Urban governance is generally carried out by decision-makers, who are individuals with professional or civic power who are responsible for developing and implementing policies [59]. Policymaking refers to the process of creating regulations, whether in the public or private sector, that guide and regulate collective endeavors aimed at promoting the welfare of individuals [60,61]. The limited availability of ecosystem services indicates that incorporating them into legislation is difficult and, to a certain degree, not widely acknowledged [62,63]. The problem is particularly noticeable when it comes to CES research, as it involves the specific task of connecting research with decision-making, setting it apart from other ecosystem services [64]. However, several experts contend that CES may have relevance in the process of making decisions [54]. Furthermore, BGI provides a hopeful approach to lessen the urban heat island impact. Urban green infrastructure has the potential to decrease urban temperatures, mitigate pollutants, and serve as habitats for wildlife, among other advantages [51]. Moreover, blue-green infrastructure plays a vital role in improving urban resilience, particularly in addressing pressing issues such as floods, increasing sea levels, and heatwave resilience [65]. The public perception and health component highlights the ecological advantages of BGI by offering a range of ecosystem services that improve the physical and psychological well-being of urban dwellers. Environmental elements, such as the caliber and availability of natural areas, have a pivotal impact on promoting physical activity, resulting in a multitude of health advantages. Empirical research has extensively recorded the beneficial outcomes of engaging in physical activity on one's health, encompassing its influence on cardiovascular disease, diabetes, colorectal cancer, osteoporosis, depression, and injuries caused by falls [66]. Furthermore, green spaces play a role in enhancing psychological well-being and promoting improvements in mental health [67]. Furthermore, these advantages may potentially have an enduring beneficial effect on an individual's lifespan. The correlation between green spaces and health can be divided into three domains, each emphasizing a unique role of green spaces: environmental threats reduction (such as reducing exposure to air pollution, noise, and heat), resilience (such as aiding in attention restoration and physiological stress recovery), and constructive capacity (such as promoting physical activity and fostering social cohesion). It is important to acknowledge that these areas are interrelated, and the interaction between them has been acknowledged [48]. Furthermore, numerous rigorous studies have shown that being exposed to a wide range of microorganisms might result in benefits in health, specifically by reducing the occurrence of allergies and respiratory disorders [68].

3.3. Highly Cited Literature

Through an analysis of citation counts, we observe that the most prominent focus in current CES research lies in exploring the various benefits derived from ecosystem cultural services and discussing methods for assessing these benefits.

The research methods in CES predominantly include direct or indirect mapping studies through spatial measurement methods such as remote sensing, model establishment (macro-ecological models, statistical models, and conceptual models), individual interviews, participatory mapping (PPGIS), or focus group questionnaires, as well as hybrid approaches integrating methods from different disciplines [69]. These research methods have been consistently used and actively incorporate new methodologies. Assessment methods for CES values mainly involve monetary, non-monetary, or a combination of both [54]. As research progresses, the perspective of CES assessment has shifted gradually from emphasizing the biophysical assessment of ecological attributes and their intrinsic values to focusing on the economic attributes and their utility values in economic assessments, and further towards the consideration of social-cultural attributes and their non-utility values in social assessments [70]. Quantitative methods have also transitioned from indicator statistics to a combination of statistical and spatial analyses [71]. Research content has evolved from assessing the societal importance of ecosystem services and analyzing group and regional differences in benefits to identifying ecosystem service relationships, analyzing influencing factors, and interpreting policy effects [72].

Currently, CES-related research is being conducted through various approaches, including spatial mapping, spatial analysis, and social media data analysis. Among these, spatial analysis of CES aids urban decision-makers in improving city BGI more effectively [73]. A study conducted by Yujia Zhai et al. in 2023 in Shanghai revealed correlations between the spatial distribution of elderly individuals and park design features [74]. Additionally, an increasing number of studies are beginning to consider facade street view images and utilize machine learning methods to analyze various types of images or textual data.

Social media analysis as a novel method for depicting and evaluating CES has also garnered attention, whether through the application of InVEST entertainment models or direct analysis of social media data within GIS applications. These data provide crucial tools for CES assessment, effectively summarizing ecosystem cultural services. Social media data are more valuable than traditional survey methods as they offer information about the types, quantity, and scale of CES [75]. However, it is important to note that the results of social media analysis may not represent all societal groups and may not cover remote or less-accessible areas [76]. Nevertheless, social media data are suitable for measuring CES demand. Qianzi Jiang et al. found correlations among different CES categories through the analysis of online review data, discovering that ecosystem services are repeatedly and simultaneously perceived across time and space [75]. In 2023, Haiyun

Xu et al. utilized social media camping data in the Beijing area to map patterns of public camping behavior in urban green spaces, evaluating spatial clusters of high/low CES (CES categories) and examining relationships between CES, local landscape features, and gender through corresponding analyses [77].

CES researchers are actively advancing interdisciplinary collaboration with disciplines such as urban geography, economics, ecology, health sciences, psychology, sociology, and design. The focus of research has shifted from single-level beneficiaries to multi-level and high-level beneficiary groups [72,78]. Yaella Depietri et al. evaluated urban cultural ecosystem services through interdisciplinary methods using public participation GIS and geolocated social media data [76]. Maximilian Nawrath et al. explored pathways linking green spaces to mental health in low-income countries through participatory videos, focus groups, and Q-methods, emphasizing the importance of ecosystem cultural services in alleviating the burden of mental illness [79].

Despite the presence of some comparative studies on cultural ecosystem services valuation applied in blue-green infrastructure on a global scale, the existing literature predominantly focuses on developed countries in Europe and North America. There is also a dearth of information of the cases studies from developing countries [80]. Additionally, the majority of the existing studies that have already been done on the application of cultural ecosystem services in urban blue-green infrastructure have been on urban green infrastructure [81–83], with limited knowledge available on green and blue infrastructure in rural and coastal areas [84]. Additionally, current studies tend to focus on larger urban blue-green infrastructure, such as urban integrated parks, riverfront green spaces, urban wetlands, and forests, with insufficient attention to smaller urban blue-green infrastructure, such as community parks, pocket parks, and street green spaces [17] (Table 2).

Table 2. Ranking of citations.

Serial Number	Clustering	Author	Article Area	Journals	Title	Number of Citations
1	2	Wolch, J.R.	USA	*Landscape and Urban Planning*	Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough [53]	312
2	7	Díaz, S.	USA	*AAAS*	Assessing nature's contributions to people [37]	222
3	0	Daniel, T.C.	USA	*PNAS*	Contributions of cultural services to the ecosystem services agenda [36]	203
4	7	Costanza, R.	Australia	*Ecosystem Services*	Twenty years of ecosystem services: How far have we come and how far do we still need to go? [35]	194
5	0	Chan, K.M.	USA	*Ecological Economics*	Rethinking ecosystem services to better address and navigate cultural values [33]	186
6	1	Meerow, S.	USA	*Landscape and Urban Planning*	Spatial planning for multifunctional green infrastructure: growing resilience in Detroit [85]	186
7	0	Plieninger T.	Germany	*Land Use Policy*	Assessing, mapping, and quantifying cultural ecosystem services at community level [54]	184
8	7	Chan, K.M.	USA	*PNAS*	Why protect nature? Rethinking values and the environment [86]	171
9	7	Pascual, U.	Spain	*Environment Sustainability*	Valuing nature's contributions to people: the IPBes approach [71]	166
10	7	Fish, R.	United Kingdom	*Ecosystem Services*	Conceptualising cultural ecosystem services: A novel framework for research and critical engagement [87]	163

3.4. Analysis of Research History

In Figure 4, terms from the same cluster are sorted along a horizontal line, allowing for a clear and efficient representation of cluster relationships. This visualization reflects the research history and current hotspots directly. Several major insights emerge from this analysis:

(1) In general, clusters occurred most frequently between 2005 and 2015, coinciding with the most comprehensive research and considerable influence on CES inside BGI applications.
(2) Some clusters that had previously wielded significant power are now receiving less attention and cooling off. Cluster 3 (urban green infrastructure), cluster 6 (cross-scale comparisons), cluster 8 (community gardens), cluster 10 (integration of ecosystem services), and cluster 16 (knowledge production) are notable examples.
(3) In contrast, clusters begun later in the research timeline have maintained significant levels of interest and influence in recent years. Cluster 1 (nature-based solutions), cluster 2 (urban green space), cluster 4 (human physical and mental health), cluster 5 (social media), cluster 7 (relationship value), and cluster 11 (urban heat island) are among them.
(4) In addition, Cluster 0 (ecosystem services) has received significant attention since its start.

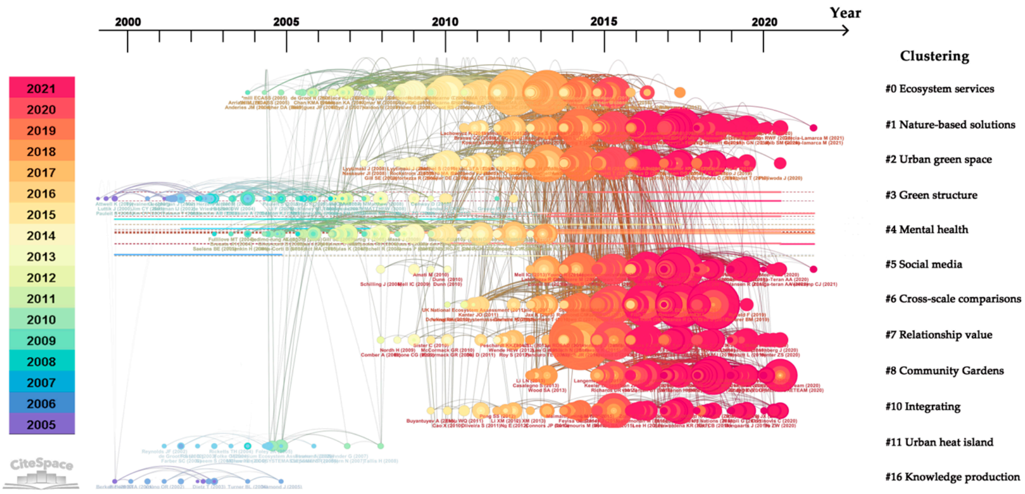

Figure 4. Time line of the outbreak of related literature studies in different clusters.

3.5. Research Keywords

Based on algorithms of keywords in CiteSpace software via bursty and hierarchical structure [88], we filtered and summarized the article content to develop relevant keywords that accurately convey the research themes of each article. In Figure 5, 'Year' represents the first appearance of high-frequency keywords within the period we analyzed, 'Strength' represents the relative frequency of the term in the literature of the same period, and 'Begin' and 'End' correspond to the start and end of the high-intensity appearance of the keyword, respectively. High-frequency keywords, as well as developing keywords, are important in identifying research hotspots.

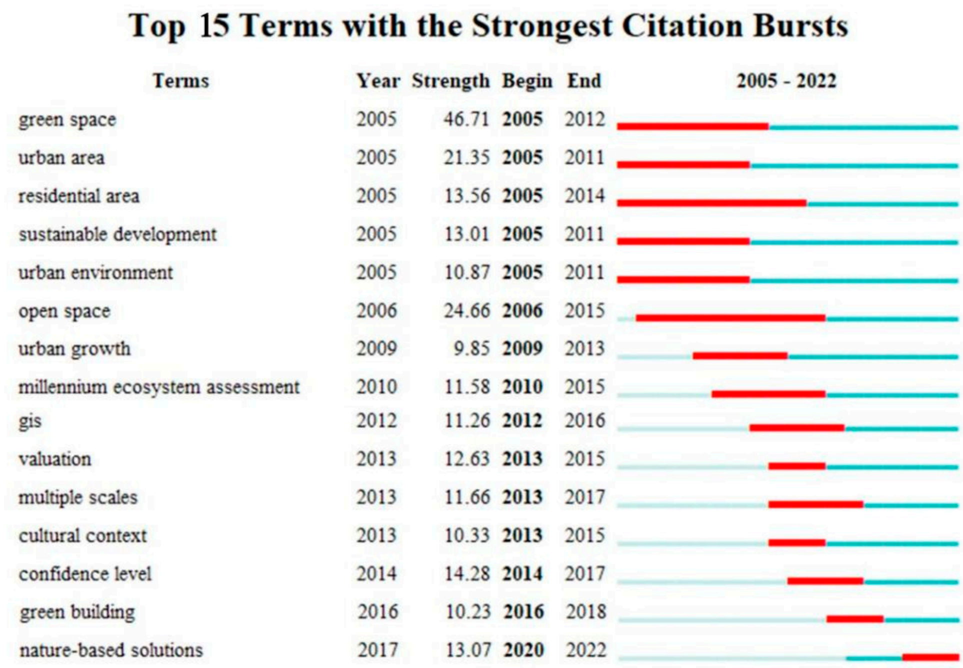

Figure 5. Top15 high-frequency keywords and their bursting time diagram.

3.5.1. High-Frequency Keywords

Figure 5 depicts the extraction and visual representation of the top 15 keywords based on frequency. The emergence of high-frequency keywords is primarily centered between 2005 and 2015. The keyword 'green space' is the most frequently used, followed by 'urban area', 'residential area', 'sustainable development', 'urban environment', and 'open space'. These frequently used keywords cover significant research areas, directions, methodologies, material, and the general field of study for cultural ecosystem services applications in BGI. Much of the study in this field relies around these important terms.

Between 2005 and 2015, the research focused mostly on existing urban green spaces, particularly in urban residential areas. Between 2010 and 2015, there was a noticeable movement toward incorporating new research tools (e.g., GIS), measuring ecosystem services, and researching nature-based solutions for improving urban environments.

3.5.2. Emerging Keywords

Emerging keywords are topics that have received a lot of attention in a short period of time, providing insights about current research patterns and future directions. Analyzing these emergent keywords provides significant information about the research field's evolving terrain.

Figure 5 depicts the emergence of high-frequency keywords throughout time. Among the significant developing buzzwords during the last decade are 'value assessment', 'multi-scale', 'cultural context', 'confidence level', 'green building', and 'nature-based solutions'. These terms point to a shift in study focus toward assessing the value of ecosystem services, particularly cultural ecosystem services with intangible effects. Furthermore, recent research trends emphasize novel BGI components such as 'green building' and ecologically centered 'nature-based solutions'. These keywords characterize the current research frontier and projected directions.

4. Discussion

4.1. Uneven Distribution of BGI Types

We see a common tendency in the body of research on the application of cultural ecosystem services in urban blue-green infrastructure to focus cultural ecosystem services assessments on larger BGIs, such as expansive forests and integrated parks. Smaller urban green areas that are readily available to the public, such as gardens, neighborhood parks, and riverfront walks, have gotten less attention [89]. People's views and preferences are strongly linked to cultural ecosystem services judgments. The multidimensional urban context, with its numerous stakeholders, offers obstacles in evaluating CES, because urban dwellers frequently have distinct cultural ecosystem service interests and preferences [90]. As a result, the majority of cultural ecosystem services investigations have been carried out in natural ecosystems with relatively similar characteristics, with limited findings in urban settings, particularly in Asian cities [91]. Furthermore, our investigation revealed little or no study on various BGI kinds, such as green roofs, green walls, and waste greening, in some circumstances.

Furthermore, we discovered an unequal geographical distribution of BGI studies that included CES assessments. This discrepancy is particularly noticeable when viewed from a global viewpoint. The majority of BGI and CES evaluation research is concentrated in English-speaking countries, primarily Europe and the United States. Non-English-speaking countries, on the other hand, have less relevant studies, with a noteworthy concentration of research papers happening later in the data gathering time, especially after 2015. Notably, Chinese scholars first became interested in CES in 2016, resulting in a small number of studies within the country [65]. However, because the origins of ES and CES research are entrenched in Europe and the United States, there is a natural tendency to emphasize English-language sources during our research article gathering process. As a result, the observed geographic bias may be attributed in part to the specific language and publishing circumstances of our study.

4.2. Unevenness of CES Categories in BGI

The number of studies on the application of cultural ecosystem services in urban blue-green infrastructure has grown exponentially. The distribution of research areas, on the other hand, has to be more balanced, with changing attention directed on different research categories. Cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social interactions, local features, heritage values, recreation, and ecotourism are the currently divided eleven major categories. Recreation and ecotourism have gotten significantly more attention than other cultural ecosystem services areas [9]. Furthermore, the classification borders between these many cultural ecosystem services categories frequently require clarification, leading to categorization problems. Many researches use the MEA categories and categorizations established in 2005 [92]. While other classification systems exist, such as The Economics of Ecosystems and Biodiversity (TEEB), the Common International Classification of Ecosystem Services (CICES), and the Final Ecosystem Goods and Services Classification System (FEGS) [93], the MEA shares a significant conceptual similarity. Researchers, on the other hand, tend to modify cultural ecosystem services categories to their unique study. For example, in studies evaluating leisure and ecotourism, 'leisure' and 'tourist' are frequently viewed as distinct concepts. For example, Ko and Son [94] conducted a CES study aimed at city residents rather than non-residents such as visitors, leading them to differentiate between leisure and ecotourism.

As a result, adopting numerous categorization systems remains important and encouraged in order to thoroughly identify and grasp the diverse cultural services, given the scarcity of information in this field [95,96]. Furthermore, multiple investigations have highlighted double counting as a typical issue that leads to mistakes and ambiguities. This difficulty leads to the need for cultural ecosystem services to be more visible. To mitigate this, clear definitions and classifications are practical solutions [35]. Nonetheless, given the inherent difficulties in defining and quantifying abstract concepts such as perception or knowledge systems, putting them into precise terminology remains a challenging undertaking. Scholars should endeavor to present more precise definitions and classifications in future CES research, as well as to establish common, simply understandable, and standardized evaluation standards that enable implementation and accessibility.

4.3. Research Directions for the Application of Cultural Ecosystem Services in Urban Blue-Green Infrastructure

Our study investigated probable future directions in CES and BGI research by assessing research clusters based on high-frequency and emergent keywords. Cultural ecosystem service research often focuses on public perception and health, with an emphasis on the urban green space environment (BGI). This field is constantly integrating new research approaches and tools. Our examination of the publications housing this material and the research methodologies used suggests a progressive movement in the research environment toward interdisciplinary collaboration and the use of novel research methodologies in applying CES inside BGI.

According to our findings, research on the use of cultural ecosystem services in urban blue-green infrastructure has been increasingly focusing on multidisciplinary collaboration and the use of novel research approaches. For example, gathering social media data to measure users' ambient views of BGI has developed as an innovative cultural ecosystem services evaluation tool. Furthermore, over the last decade, research has indicated an increased interest in novel BGI typologies, such as green buildings and ecologically oriented nature-based solutions, indicating an emerging research trend.

4.4. Research Gaps and Outlook

We must acknowledge that although we conducted an article search using the specified keywords, they may not have allowed us to include all pertinent studies on the applications of cultural ecosystem services in urban blue-green infrastructure. As a result, our conclusions may contain certain limitations. Moreover, the main emphasis of our research was on English articles written in a single language, potentially leading to the introduction of biases into our results. An example of this can be seen in the uneven distribution of BGI studies that included CES assessments across different geographic locations. This discrepancy may have been caused by our data acquisition bias towards literature written in the English language.

The following are suggestions for further investigation in this field:

(1) Subsequent inquiries ought to broaden their scope by scrutinizing distinct varieties of BGI across numerous cities globally, encompassing even individual municipalities. This methodology promotes the investigation of diverse forms of BGI, with a particular emphasis on those that have been overlooked in previous studies or have research gaps that are directly applicable to individuals' daily lives, such as green roofs or street greening [60]. Furthermore, we advocate for researchers to perceive BGI as a network that is interconnected and to examine the functioning of CES within this network.

(2) In recent times, urban blue-green infrastructure research has diversified its focus from aesthetic and entertainment values to encompass educational and cultural heritage values as well [9]. This observed pattern indicates a growing emphasis on the inclusion of diverse services in cultural ecosystem services research. Further investigation into various forms of cultural ecosystem services should be the focus of future research to encompass all cultural ecosystem service values and, ultimately, to provide more robust support for practical applications.

(3) It is critical to develop additional methods and techniques for evaluating cultural ecosystem services that are tailored to BGI contexts. By establishing unambiguous boundaries for the BGI and clarifying the interconnections among various cultural ecosystem service components, for instance, one can mitigate the risk of errors and uncertainties that may arise from redundant computations throughout the research endeavor [65].

(4) Indicators of cultural ecosystem services ought to be formulated in a manner that is readily understandable to stakeholders, including policymakers and citizens. These indicators are of the utmost importance in promoting environmental protection awareness. An illustrative example is the notion of 'landscape openness' proposed by De Valck et al. [97], which functions as a metric for outdoor recreation and incorporates

vegetation cover of varying degrees to symbolize distinct levels of openness. Indicators that are precisely defined and employ standardized classifications ought to garner greater interest and be the subject of additional discourse among researchers.

Further investigation into the implementation of these suggestions could strengthen and expand the scope of cultural ecosystem service studies pertaining to urban blue-green infrastructure applications.

5. Conclusions

Our study summarized the application status of cultural ecosystem services in urban blue-green infrastructure based on our analysis performed utilizing CiteSpace. The application of CES in the framework of BGI exhibits considerable promise. However, unexplored research potential persists in the application of cultural ecosystem services in urban blue-green infrastructure.

We have found that current research on the application of cultural ecosystem services in urban blue-green infrastructure exhibits an uneven distribution of BGI types. The assessment of CES tends to focus on large-scale BGI, such as forests and comprehensive parks, while smaller urban green spaces like gardens, community parks, and riverside trails receive comparatively less attention. Moreover, certain specialized urban green spaces, such as green roofs, green walls, and abandoned green spaces, are rarely studied or almost entirely overlooked. Additionally, there is a geographical imbalance in research, with most studies concentrated in European and North American cities, while developing countries are underrepresented. The categories of CES within BGI also exhibit an uneven distribution. While the entertainment value of CES receives significant attention, aspects such as the sense of place and cultural heritage are often overlooked. Furthermore, there is a lack of consistency in CES classification and evaluation systems. Currently, research on CES faces issues of classification inconsistency, with no standardized guidelines for naming categories. Researchers may modify existing CES categories or create new ones, leading to variation in the number of categories across studies, typically ranging from seven to twelve. Uncommon or hard-to-define CES categories are often omitted. Additionally, there is no unified standard for assessing the value of CES, resulting in diverse evaluation methods. Furthermore, in many countries and regions, policymakers have not actively integrated CES evaluations into urban governance practices.

To sum up, we view this review as a crucial step toward understanding the current application of cultural ecosystem services in urban blue-green infrastructure. It also provides valuable insights for future planning strategies related to the integration of cultural ecosystem services in this context.

In order to progress the implementation of cultural ecosystem services in urban blue-green infrastructure, the following aspects are proposed for future research:

(1) To investigate a wider range of urban BGI varieties. The broadening of the scope should incorporate diverse aspects of ecological infrastructure in urban areas. (2) To give thorough consideration to the CES. Further investigation is warranted to encompass all classifications and facets of CES in order to attain a more comprehensive comprehension of their relevance to BGI. (3) To incorporate CES application research into urban governance practices. To accomplish this, we propose a more flexible and effective strategy that is customized to the particular requirements of urban governance. (4) To improve the physical health and well-being of urban residents by targeted implementation of CES. More research should be devoted to the development of targeted interventions and strategies to accomplish these health-related objectives.

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