GLOBAL POLICIES ON GREEN BUILDING CONSTRUCTION FROM 1990 TO 2019

A Scientometric Study

Tahereh Khademi Adel,[1] Leyla Pirooznezhad,[2] Mehdi Ravanshadnia,[3] Abbas Tajaddini[4]

ABSTRACT

Green Building Construction (GBC) is considered as an advancement towards sustainable development and providing a balance among health, economics, and social problems. Many countries have adopted various policies for GBC according to their conditions and regulations, including incentives and deterring programs. This study reviews a scientometric analysis of some published articles on the policies, incentives, and barriers to GBC from 1990 to 2019. The required data has been collected from the Web of Science (WoS) database, and then analyzed using Histcite, CiteSpace, and VOSviewer software. To accomplish this study, many items have been identified and ranked such as top journals, keyword co-occurrence networks, cluster analysis, the strongest citation burst, co-citation articles, most citations per year, and countries' contribution to publishing, for the last three decades. Examining the trend of changes in publication of the related papers and interpretations of the analyses can be used for future research in each of the components, in addition to the creation of a knowledge-based view of past studies.

KEYWORDS

green building construction (GBC), policies, incentives, scientometric

1. INTRODUCTION

Due to world population growth, and the limitedness of natural resources, it's inevitable to adopt new methods and solutions which meet the essential requirements of societies without affecting sustainability in the future (Sharp et al., 2014). Building construction could affect the economy, health, natural environment, and productivity of a society (Taemthong and Chaisaard, 2008). Its effects on the environment are overuse of natural resources such as energy, water, soil, and other materials. Furthermore, an increase in the amount of greenhouse gas emission and

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air pollution as a result of construction activities has led to more waste and wastewater production since the worldwide energy crisis in the early 1970s. The first environmental movements emerged in the USA and Europe, and green building rating schemes were established in the early 1990s (Goulden et al., 2017), (Cohen et al., 2017).

Following the efforts of scientists and industrial activists, in 1994 the first international sustainable building conference was held in the USA,[5] and a new discipline for sustainable buildings was established (Hil RC, 1997) which for the first time presented the concept, framework, and principles of a sustainable building (Liu et al., 2020). Various assessment tools were produced to assist green buildings in development (Siva et al., 2017). Among the most important standards widely used are Leadership in Energy and Environmental Design (LEED)–USA, Building Research Establishment Environmental Assessment Method (BREEAM)–UK,[6] Green Star–Australia, Green Building Index (GBI)–Malaysia, and Green Globes (Zuo and Zhao, 2014). In 1990, BREEAM[7] was established in England, and in 2005 LEED[8] was introduced in the United States (Cohen et al., 2017). The LEED system deals with categories like sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality (Keeton, 2000). The above assessment tools for green building evaluation are voluntary and not compulsory at the moment (Zuo and Zhao, 2014). Although 195 countries have signed the Paris Agreement, intending to strengthen the global response to the threat of climate change in December 2015 (Tsai et al., 2017), 40% of energy, 12–16% of available water, 32% of non-renewable and renewable resources, 25% of wood, and 40% of raw materials are still consumed in building construction around the world. Further, 30–40% of solid waste, and 35–40% of greenhouse gases are produced by building construction activities (Liu et al., 2020). Global carbon emissions are expected to reach about 42.4 billion tons by 2035, due to the same upward trend, which shows an increase of about 44.3% compared to that of 2007 (Zuo and Zhao, 2014). Because of the increasing importance of the global climate change issue in the past decade, Green Building Construction (GBC) received increased attention by both policymakers and environmental economists (Licence, 2017). According to the US Green Building Council (US[9]GBC[10]), a green building is a building with a comprehensive approach to plan, design, construct, operate, and finally recycle an old structure or to renew it with consideration of such issues like energy use, water use, quality of the indoor environment, type of the selected material, and the building's impact on the construction site (Hankey, 2019), (Taemthong and Chaisaard, 2008). Furthermore, the cost savings provided from reduced energy and water consumption, better operation and maintenance, and also the well-being and productivity of the inhabitants can be promoted in green buildings (Azeem et al., 2017) (Tsai et al., 2017).

Due to the advantages of GBC, there is a need for policies and incentives to attract building sector stakeholders to adopting green buildings (Yin and Li, 2018). Among the challenges of adopting GBC are the cost and financing issues (Chan et al., 2015). Also, special mortgage incentives could be used as a motivation to seek green certification of buildings (Portnov et al., 2018). Globally, various policies have been implemented to encourage the development of GBC. Government involvement is considered an important way for improving the development of GBC including incentive programs, GBC certification systems, the imposition of carbon

5. United States America
6. United Kingdom
7. Building Research Establishment Environmental Assessment Method
8. Leadership in Energy and Environmental Design
9. United States
10. Green Building Construction

taxes, etc. (Shazmin et al., 2017). First, governments could increase local demand for GBC by clarifying its role in environmental protection or by establishing a special standard to assess the performance of GBC. Second, procurement policies imposed by government could result in reduced prices for GBC inputs by a combination of some means, like an enhanced entry of new, green building suppliers, scaled economies, and learning effects. Third, applying government procurement policies could result in the adoption of green buildings with the solution of the coordination challenge in the market. (Simcoe and Toffel, 2014) C. He et al., (2018) demonstrated that the floor-to-density award, the GBC requirements, and interest rate are importanct factors for stimulating the developers'willingness to pursue GBC. Concerning the policies' subseries, compulsory requirements have a greater impact than voluntary incentives in terms of stimulating developers. The financial incentives in China were more impressive than non-financial ones; thus, policymaking efforts have directed towards attracting developers to GBC (He et al., 2018). H. Liu et al., (2016) have concluded that innovations in technology alongside reforming of energy pricing, taxation policies, and other regulations associated with the environment are drivers for stimulating interest in GBC (Liu and Lin, 2016). By comparing the successful policies and models adopted in many countries around the world, S. Hashim et al., (2016) showed that in Malaysia, green building policies should focus more on construction incentives, including technical supports, accelerated building permit issuing, and Gross Floor Area (GFA) equivalent incentive schemes (Hashim et al., 2016). Therefore, all motivating factors that develop GBC, and restraining policies such as fines and taxes which have a reverse effect on adopting GBC are considered as Green Dwelling (GD) policies. The policies are generally classified as positive and negative incentives. According to the literature, positive incentives are usually offered as initiatives for promoting GBC by the authorities and include economic, technical, and legal incentives. Financial or economic incentives can refer to property tax assessments, development costs, and grants. Legal and technical incentives include different support means such as marketing, technical consultancy, accelerated permit-issuing procedures, and density premiums. Romania, Spain, Italy, United States, Bulgaria, Canada, India, and Malaysia have offered financial incentives, especially property tax assessment incentives such as reductions, privileges, and discounts for GBC development (Shazmin et al., 2017). Another challenge that has been questioned by some researchers is whether the incentives provided by government could be effective in GBC development or not (Gundogan, 2012). Therefore, local governments should implement empirical studies on the effectiveness of these incentives in the local housing market by analyzing the cost and benefit of various plans and policies to offset green building costs in advance, in association with affordable green housing. (Hankey, 2019).

On the other hand, negative incentives such as tax incentives have an indirect high impact on the development of GBC. The programs range from residential efficient appliance incentives to large business complexes which are recognized as "Green" buildings. These types of tax incentives are efficient tools available to governments by which developers are encouraged to utilize advanced building codes, and also standard appliances and equipment by reducing the cost of using new technologies, and at the same time by increasing their market share (Brown et al., 2002). These incentives must be requested for the building industry, and also be easily executed by governments (Qian et al., 2016). Also, the carbon taxation policy recommended by economists and scientists is an affordable way to attain the goal of greenhouse effect reduction (Tsai et al., 2017). Y. Zou et al. (2017) demonstrated that subsidies and local policies for economic incentives could justify the construction of green buildings (Zou et al., 2017).

Most global research on GBC policies has been conducted as applied studies for the specific conditions and laws of each country. Therefore, this study provides a scientometric review

of research conducted on global GBC policies, including different types of policies such as motivations, drivers, or barriers during the years 1990 to 2019.

2. METHODOLOGY

2.1 Scientometric analysis

In this study, three main techniques including scientometrics, informatics, and bibliometric analyses have been used to review the GBC policies during the years 1990 to 2019 (Wuni et al., 2019). Scientometrics is measures and analyses scientific literature and has adopted distinct methodologies and lines of inquiry (Serenko et al., 2010). In a scientometric analysis, various bibliometric data, techniques, and methods are utilized for the scientific mapping of literature (Wuni et al., 2019). It was developed by distinguished scholars such as Derek J. de Solla Price, Robert King Merton, and Eugene Garfield (Serenko et al., 2010). Science mapping or visualizing a bibliometric network is a generic process of domain analysis and visualization. It is a way to mining a field of research or a scientific discipline using statistical methods (Liu et al., 2020), (Wuni et al., 2019).

There are various science mapping tools for analysis and visualization of structural, dynamic, or temporal patterns within the knowledge domain (Wuni et al., 2019). Hiscite, CiteSpace, and VOSviewer science mapping tools are utilized in this study. The HistCite software, developed by Garfield and his team, assists users to identify core literature from the Web of Science (WoS) databases (Liu et al., 2020). It pinpoints the most-cited articles and evaluates the subsequent impact of those citations (Maditati et al., 2018). The VOSviewer software also provides access to bibliometric networks using the available data from Dimensions, Scopus, and WoS[11] (Darko et al., 2019). The CiteSpace software is a tool for visual exploration of scientific literature and incorporates it to create interactive visualizations with the purpose of scientometric analysis of knowledge in the scientific literature. The visual analysis could improve analytical reasoning through visual interaction (Serenko et al., 2010), (Liu et al., 2020).

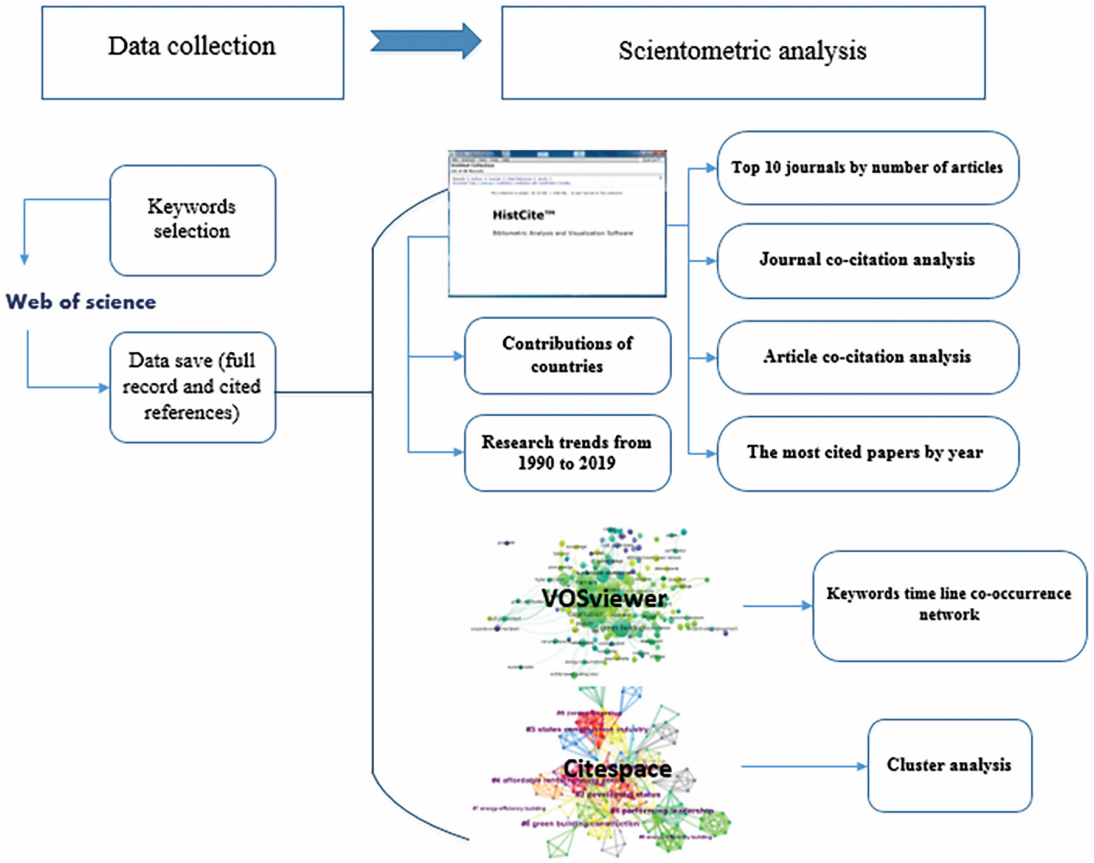
2.2 Data collection

The WoS core, is a comprehensive source for citation, indexing, and citation analysis containing the most important journals and scientific publications in many fields of science (Zhao et al., 2019). Scopus is another important database with some overlapped topics observed between them (Chen et al., 2018). The WoS covers a wider range of publications that comprise engineering, science, management, humanities, and social sciences, so it was utilized for the data collection in this study (Zhao et al., 2019). All the articles in this core collection database were studied in this research, which consists of the most important and influential journals worldwide, and includes most publications on GBC policies (Zhao, 2017).

First, the main keywords and phrases related to green building policies, incentives, and barriers were searched. The search was limited to the period of 1990–2019. The keywords included: 'green building,' 'policies,' 'incentives,' 'implementation,' 'financial incentives,' 'tax policy,' 'drivers,' 'motivators,' and 'barriers.' As the green building topic is vast, the searched articles were limited to policies, incentives, and barriers related to green buildings in the WoS database. As an example, the retrieval code presented below was implemented for searching the WoS core collection:

11. Web of Science

FIGURE 1. Research methodology flowchart.



TS/TI= ("green building" AND* incentives)

In the above code, "*" denotes a fuzzy search, "TS" represents an article topic and "TI" represents an article title (Zhao, 2017). In this research, the papers, books, and editorials on the conference stages were omitted from the study; only research articles and their results were examined. For comparison purposes, the search was performed by 'Title Research' and 'Topic Research.' 'Title Research' was more related to GBC policies. Therefore, both of the above subjects were searched. After data collection, the relation of each article to the field was controlled manually. (Khademi Adel et al., 2021) Figure 1 shows the steps for both data collection and scientometric analysis, including the titles and utilized software.

3. RESEARCH RESULTS

3.1 Top 10 journals by the number of articles (1990–2019)

The results of a scientometric survey using the Histcite software on selected data are shown in Table 1, which includes 95 articles published in 50 journals with 237 authors and 3951 cited references for ranking the top journals in terms of the number of related articles published. The *Journal of Green Building* with 13 related articles and about 27% of the selected published articles ranked first in the field of Green Building's Policies, Incentives, and Barriers from 1990

TABLE 1. Top 10 journals ranked by the number of articles (1990–2019).

No	Journal Name	Number of papers	%	H Index	Impact factor
1	Journal of Green Building	13	27.08	19	0.27
2	Sustainability	8	16.67	68	0.58
3	Building and Environment	7	14.58	138	1.87
4	Journal of Cleaner Production	4	8.33	173	1.89
5	Renewable and Sustainable Energy Reviews	4	8.33	258	3.63
6	Building Research and Information	3	6.25	79	1.18
7	Energy Policy	3	6.25	197	2.17
8	Smart and Sustainable Built Environment	2	4.17	12	0.26
9	Energy and Buildings	2	4.17	166	2.06
10	International Journal of Construction Management	2	4.17	19	0.57
	Total	48	100%		

to 2019. The findings indicate that journals with higher Hirsch Index (H Index), Impact Factor (IF), do not necessarily have top rankings, for example, the *Journal of Renewable and Sustainable Energy Reviews* with the highest value of H[12] Index (Brandão and Soares de Mello, 2019) and Impact Factor ie 258, 3.63 is in the fifth place in the ranking table. Therefore, the H Index and Impact Factor alone do not express absolute criteria to select a journal for publishing scientific research, and this issue provides more chances for other journals to have scientific activity and competition.

3.2 Journals co-citation analysis

The importance of using citations in research is to measure different aspects of knowledge-based achievements and the possibility of comparison, as well as to rank various variables, including authors, journals, etc. (Aljuaid et al., 2020). In this step, the journals are analyzed and ranked in terms of the number of citations accomplished to their published articles. This analysis is based on the maximum citation per article, obtained by dividing the total citations of relevant articles in that journal by the total number of relevant articles published. In Table 2, the top ten journals in the field of green building policies, incentives, and barriers during the years 1990 to 2019 are ranked in terms of citations per article from the selected data. As seen, some journals with having only one hot-cited published article, are in higher rank compared to other journals with more articles. Therefore, it seems that the number of published articles necessarily does not result in a higher ranking. For example, the *Journal of Building and Environment* is in seventh

12. Hirsch Index

TABLE 2. Top 10 journals by citation per article (1990–2019).

No	Journal name	Total citations of relevant articles	Total number of relevant articles	Citation per article
1	Organization and Environment	166	1	166.00
2	Sustainable Development	155	1	155.00
3	Resources Conservation and Recycling	40	1	40.00
4	Renewable and Sustainable Energy Reviews	151	4	37.75
5	Review of Environmental Economics and Policy	34	1	34.00
6	Academy of Management journal	33	1	33.00
7	Journal of Cleaner Production	128	4	32.00
8	Building and Environment	219	7	31.29
9	Journal of Environmental Economics and Management	29	1	29.00
10	Journal of Planning Education and Research	27	1	27.00
	Total	982	22	44.64

place with 7 articles and 219 citations. Therefore, the criterion of journal co-citation, to cite the research, may be more appropriate in selecting journals.

3.3 Article co-citation analysis

The results of the article co-citation analysis have been presented in Table 3. The first article, with 166 citations, was published in 2008 in the *Organization and Environment* journal. After surveying the three levels of barriers (i.e. individual, organizational, and institutional), using specific strategies, the mentioned article suggests some solutions to overcome these obstacles (Hoffman and Henn, 2011). The second article, which identifies common barriers observed during the management of green construction projects in Singapore, offers some suggestions to remove the barriers (Hwang and Tan, 2012). Among the other articles that have identified and examined the barriers, one was published in 2018 with 61 citations in the *Journal of Cleaner Production*. The article worked on the obstacles existing in the adoption of Green Building Technologies (GBT) in developing countries with the case study of Ghana (Chan et al., 2018). Another article with 40 citations, published in the *Journal of Resources Conservation and Recycling* in 2017, is related to GBC in Vietnam (Nguyen et al., 2017).

All other top articles have identified and examined incentives, policy implications, general Policies, and Drivers for implementation of green building (Onat et al., 2014), (Olubunmi et al., 2016), (Gou et al., 2013), (Darko et al., 2017), (Lu et al., 2012), (Matisoff et al., 2016).

3.4 The most cited articles in selected records by year

In this step, the most cited articles in selected papers are identified and classified by year that cover the identified issues in GBC research during the last three decades. As seen, there

TABLE 3. Top 10 journal articles ranked by the citation.

NO	Document title	Authors	Year	Journal	Volume (Issue)	Citation
1	Overcoming the Social and Psychological Barriers to Green Building	Hoffman AJ et al.	2008	OE	21 (4)	166
2	Green building project management: obstacles and solutions for sustainable development	Hwang BG et al.	2012	SD	20 (5)	155
3	Green building incentives: A review	Olubunmi OA et al.	2016	RSER	59	92
4	Towards greening the U.S. residential building stock: a system dynamics approach	Onat NC et al.	2014	BE	78	76
5	Critical barriers to green building technologies adoption in developing countries: The case of Ghana	Chan APC et al.	2018	JCP	172	61
6	Market readiness and policy implications for green buildings: case study from Hong Kong	Gou ZH et al.	2013	JGB	8 (2)	55
7	Drivers for implementing green building technologies: An international survey of experts	Darko A et al.	2017	JCP	145	41
8	Will green building development take off? An exploratory study of barriers to green building in Vietnam	Nguyen HT et al.	2017	RCR	127	40
9	Effectiveness and equity implications of carbon policies in the United States construction industry	Lu YJ et al.	2012	BE	49	35
10	Green Buildings: Economics and Policies	Matisoff DC et al.	2016	REEP	10 (2)	34

is no significant relationship between the years of publication and the number of citations. Furthermore, the citations vary based on the popularity of the topics in different years. An overview of the most cited topics over the past three decades can be categorized into four groups as follows.

The first category includes research that examines the incentives and drivers in the development of green buildings globally. In a systematic review study, O. Olubunmi et al., (2016), categorized the incentives of GBC into two clusters of internal incentives and external incentives, which are offered mainly from the government including financial and non-financial ones: it obtained 92 citations (Olubunmi et al., 2016). In another article, published in 2017, the main drivers of GBT[13] implementation are examined and the five main factors were specified and

13. Green Building Technologies

ranked, which are energy-efficiency, reduced environmental impact, water-efficiency, occupants' health and comfort and satisfaction, and finally company image/reputation (Darko et al., 2017).

The second category of articles examines the policies in GBC. Annie R. et al. (2007), identified the comparisons and contrasts of alternatives to green building programs in the United States, categorizing them into three parts: policy, program, and evaluation options, and then assessed their likelihood of successful implementation in the context of public agencies through considering their social, environmental, and economic implications (Annie R. Pearce, Jennifer R. DuBose, 2007). Another study, published in 2010 on the role of local governments in fostering GBC in the United States, has extended the results of research beyond simple design consulting to modify existing city programs and guidelines with a direct focus on important aspects of environmental sustainability (Theaker and Cole, 2010). An article, published in 2009, described the status and comparison of LEED policy structures, their impact on the built environment, their role, and how they work in practice in the United States (Retzlaff, 2009). The next study, conducted in 2010, evaluated the institutional green building policies in North America, using a mixed-methods approach, and found some results such as leadership, policy compliance, and barriers to sustainable building policies that could produce a framework title for sustainable organizational policies. As such, it could be used as a model for senior facility specialists and the development of their specific policies (Cupido et al., 2010). Through assessing the market for green construction developers in Hong Kong, Z. Gou et al., (2013) cited legislators as an effective driver of green building development, and as a mechanism helpful to motivate market participants (Cupido et al., 2010). The study, conducted by Onat et al. in 2014 with 76 citations, addresses three important policy areas, including high-performance GBC, building retrofitting, and new construction of zero-carbon and 19 strategies to reduce greenhouse gas emissions (Onat et al., 2014). Another article published in 2015 mentioned the role of leadership in green building policies, describing the proper functioning of local governments as effective policies and a model for appreciating and supporting the private sector, and accepting the risks of new technologies and methods. For convenience, private capital has been considered as an example of this support (Cidell, 2015).

The third category of research in Table 4 deals with the implementation of green buildings. A study in Ghana sought to provide a framework for the implementation and certification of green buildings in 2019 (Ampratwum et al., 2019). In another article, published in 2019, the governing mechanism of converting Building Material Industry (BMI) to Green Building Material Industry (GBMI) has been analyzed from the perspective of the supply and demand aspect of green building. Then green innovation subsidies as well as penalties for pollution and fraud compensation were recognized as the main mechanical systems for high-quality development (Yin et al., 2019). Financial methods for investing in GBC were compared in research, and several economic analysis methods were studied to support green building decisions, and as a result, some strengths, weaknesses, data needs, and research requirements were suggested (Wolff, 2004).

The fourth category of articles identifies and examines the barriers to the construction of green buildings (Chan et al., 2018). B. Hwang, (2012) in a highly cited article pointed out the obstacles, and solutions of the management of GBC, for sustainable development in Singapore, which has achieved 155 citations to date (Hwang and Tan, 2012). Finally, the most cited paper in Table 4 was published in 2008 with 166 citations, discusses overcoming obstacles, analyzes social and psychological barriers to GBC, and also provides the proper solutions at three levels which are individual, organizational, and institutional(Hoffman and Henn, 2011).

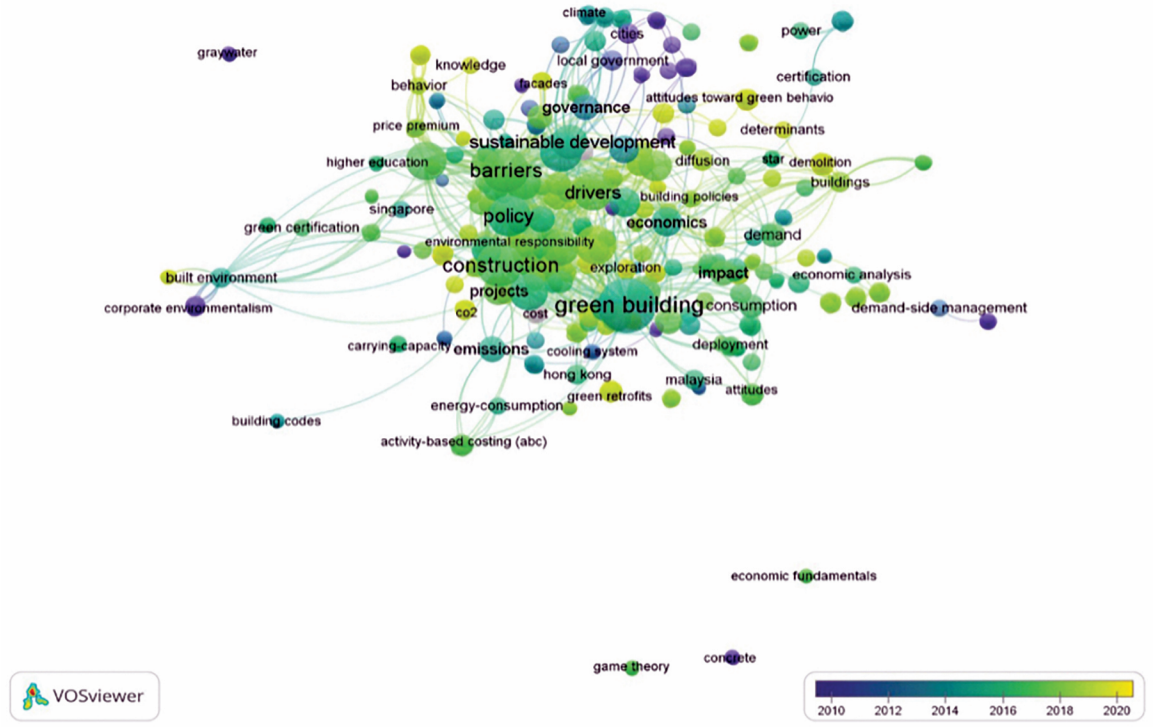
TABLE 4. The most cited articles in the selected records by year.

Year	Paper name	Number of citation
1999	A framework for the implementation of green certification of buildings in Ghana	3
2001	The role of local governments in fostering 'green' buildings: a case study	23
2002	Governing green—Increasing numbers of municipal green building programs are offering incentives for sustainable landscape architecture	2
2006	Beyond Payback: A Comparison of Financial Methods for Investments in Green Building	5
2007	Green Building Policy Options for the Public Sector	28
2008	Overcoming the Social and Psychological Barriers to Green Building	166
2009	The Use of LEED in Planning and Development Regulation An Exploratory Analysis	27
2010	Evaluating Institutional Green Building Policies: A Mixed-Methods Approach	10
2012	Green building project management: obstacles and solutions for sustainable development	155
2013	Market Readiness and Policy Implications for Green Buildings: Case Study from HONG KONG	55
2014	Towards greening the U.S. residential building stock: A system dynamics approach	76
2015	Performing leadership: municipal green building policies and the city as role model	12
2016	Green building incentives: A review	92
2017	Drivers for implementing green building technologies: An international survey of experts	41
2018	Critical barriers to green building technologies adoption in developing countries: The case of Ghana	61
2019	The governance mechanism of the building material industry (BMI) in transformation to green BMI: The perspective of green building	11

3.5 Keywords timeline co-occurrence network

In this step, the network of keywords timeline co-occurrence has provided the overlay visualization with the "full counting method" using the VOSviewer software. This network shown in Figure 2 as an output, is drawn based on 1096 items in 576 clusters with 4873 links for all keywords, which shows the "minimum threshold of keywords occurrence" has been considered once (van Eck and Waltman, 2014). The occurrence of keywords is indicated as a timeline with a color spectrum in the figure. By clicking on each keyword, the number of occurrences, the

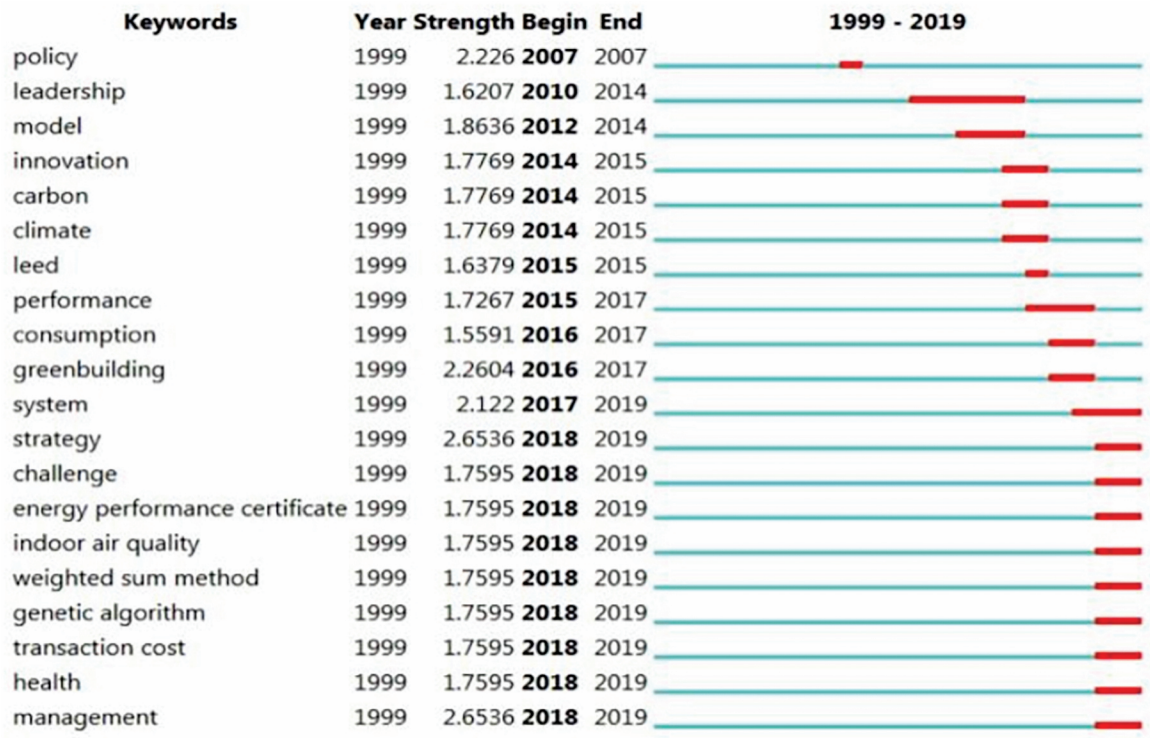
FIGURE 2. The network of keywords timeline co-occurrence.



category of related articles, and the number of related links are demonstrated, and also can be analyzed and compared, which can, in turn, indicate a good knowledge of research attention on the incentives and barriers of GBC during the period mentioned. Furthermore, the existing gaps may be used as an idea for future research.

Indeed, "citation burst of keywords" is defined as a sudden increase in the frequency and citation of a keyword over a short period, and "strongest citation bursts" represents the most citation explosions to a keyword in a short time, which can be obtained using the CiteSpace software (Chen, 2016). Therefore, a citation burst indicates that the scientific community has paid, or is paying, particular attention (Su and Lee, 2010). The results of keyword analysis for strongest citation bursts have been shown during the years mentioned in Figure 3. As seen, the keyword of "green building" in the years 2016 to 2017, with a very wide range of topics has been one of the strongest explosive citations, which includes cases such as green building policy analysis (Kuo et al., 2016), (Hopkins, 2016), (Olanipekun et al., 2017), (Xie et al., 2017), empirical studies of factors affecting the implementation of green buildings (Tam et al., 2012), intelligence policy analysis and green building development (Kuo et al., 2016), demystifying first-cost green building premiums in healthcare (Houghton et al., 2009). The research including the keyword of "strategy" during the years 2018 to 2019, for example, promoting strategy of the green building industry (Xing and Cao, 2019), or study the impact of the carbon tax policy on green building strategy (Xing and Cao, 2019) has been dedicated to the strongest citation bursts. The research containing the keyword of "management" also has been at the top within 2018–2019, having the topics of energy efficiency management (Kim and Park, 2018) and sustainable development management (Hwang and Tan, 2012).

FIGURE 3. Top 20 keywords with the Strongest Citation Bursts (2007 to 2019).



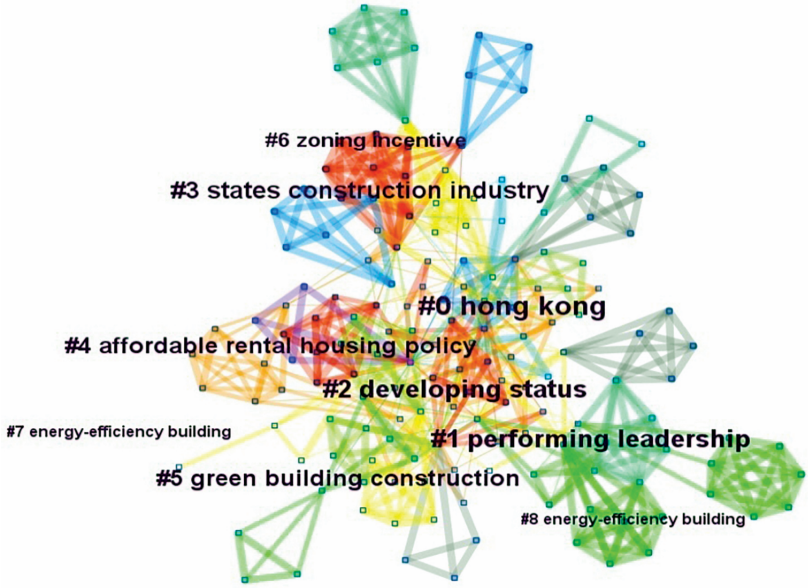
3.6 Cluster analysis

In the previous section, after analyzing the research keywords, a co-occurrence network and their strong citation burst were obtained, but the frequency and citation alone cannot be comprehensive and suitable criteria for finding the structure and classification of the subject. Therefore, cluster analysis is performed, which uses a series of algorithms to convert the selected data into several data structures, and the CiteSpace output of which is shown in Figure 4. The first step for building a knowledge domain or cluster analysis is the identification of highly cited documents using the document co-citation analysis. The second step is to perform an analysis of the documents to find the key research domain. Also, for each cluster, a label was derived from the noun phrases (Chen et al., 2010). As seen, research patterns on GBC policies are identified and depicted into 8 main areas. "Performing leadership," "developing status," "states construction industry," "affordable rental housing policy," "green building construction," "zoning incentives," "energy efficiency building," and "Hong Kong" are the main clusters. Each of these clusters demonstrate the branched schemes of GBC policies research conducted in selected data that provides a view of the centers of interest and attention to research in the field of green buildings. Clustering can even reveal knowledge gaps in areas that require more effort; it can also be useful for orienting future research.

3.7 Contributions of countries

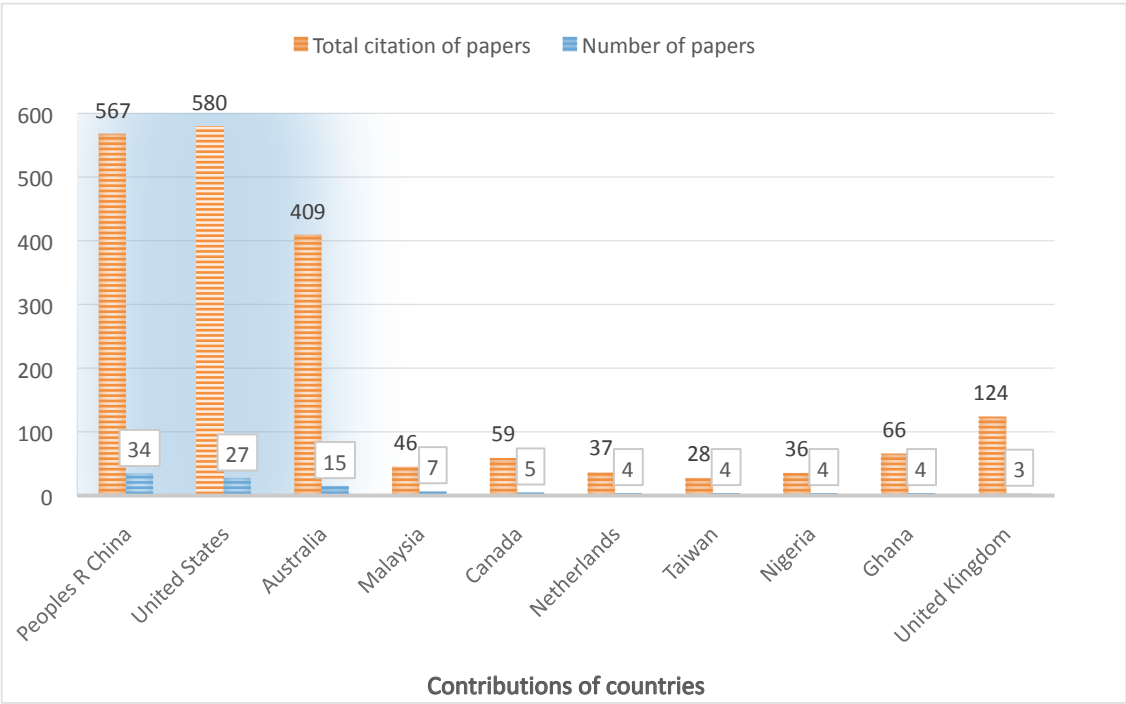
In the next step, the contribution of research-producing countries was analyzed and ranked. Among them, China came in first place with 34 articles and 567 citations. The United States and Australia have been identified as the next top countries in the production of scientific

FIGURE 4. Cluster analysis in green buildings' incentives and barriers.



articles on green building's incentives and barriers. As shown in Figure 5, there is no direct correlation between the number of articles published and the total citations of articles, and the number of citations does not necessarily change with the number of articles. Besides, Figure 5 shows that research on green building policies is conducted in developing and transitional

FIGURE 5. Top 10 countries with at least 3 articles published (1990–2019).



economies. Thus, it is not surprising that these countries are witnessing an increasing pattern in research publications (Khanna et al., 2015), (Zhang et al., 2018), (Ye et al., 2015), (Boake, 2008), (Li et al., 2013).

3.8 Trend of Green Building policies research (1990–2019)

Figure 6 demonstrates the trend of journal published articles related to GBC policies, incentives, and barriers plus their citations from 1990 to 2019. As seen, the evolutionary trend of changes in the number of articles and their citations has been upward during the last three decades. The significant increase in the number of articles during the last decade expresses the importance and attention to GBC industry. Considering the popularity of GBC in the last two decades to prevent greenhouse gas emissions and foster environmental protection, there will be an ever increasing need for continued research in this area. The increase in the number of related articles in the last two decades confirms that a new trend is emerging in scientific research on green building construction.

As discussed, in the introduction, the published articles on GBC policies can be divided into two general categories and some of this data have been mentioned in Table 5 as an example. The positive policies are incentives which include technical, legal, and financial encouragements including the motivations and reasons that encourage the designers, builders, developers, and users to choose green building construction. The examples are density bonuses, gross floor area, discounts, loans or grants, etc. The negative policies include the deterrents potentially available, such as pollution taxes, retrofitting of existing buildings, and regulating carbon output, etc., which have the effect of leading change in the green construction industry. Future studies can pay more attention to each these policy areas.

FIGURE 6. The number of journal articles published from 1990 to 2019.

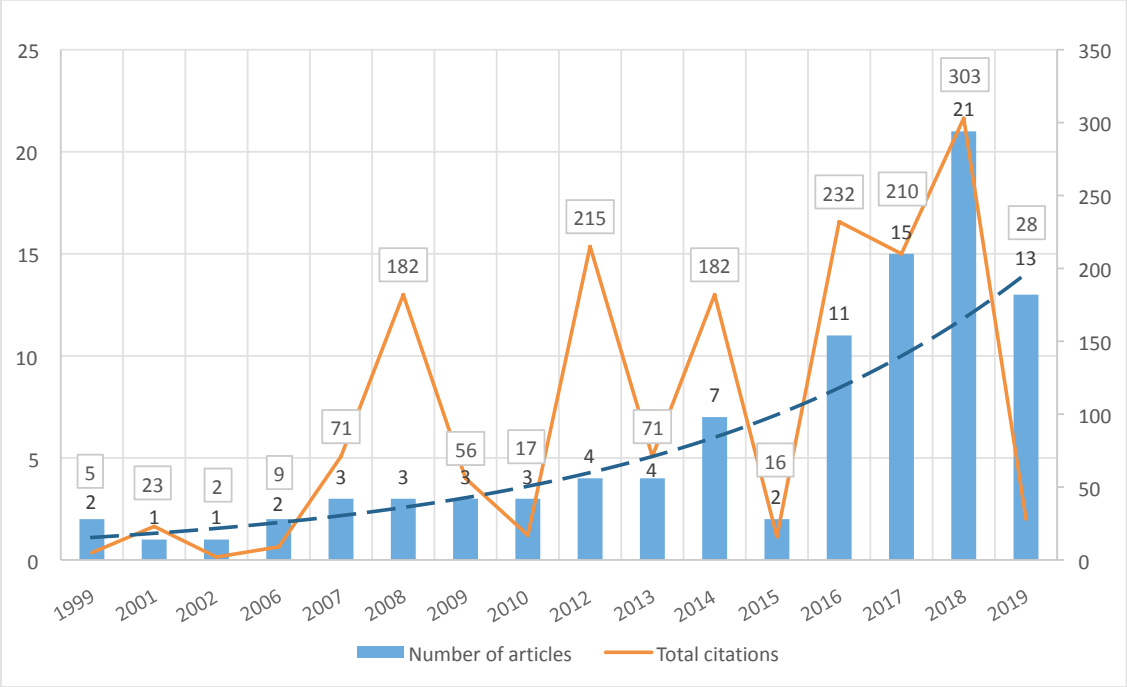


TABLE 5. Global policies on GBC.

Global Policies on GBC	Positive Incentives	Technical	Novel delivery and management approach(Shi et al., 2014)	To educate consumers to improve their willingness (Shi et al., 2014)
			Apply optimized active technologies reasonably(Teng et al., 2017)	To provide sophisticated and robust technical standards(Shi et al., 2014)
			Education on new green technologies(Azeem et al., 2017)	Using passive technologies with priority(Teng et al., 2017)
		Legal	Formal certification from a third-party organization(Sentman et al., 2008)	Improving the standard and assessment systems(Shi et al., 2014)
			Providing a sound legal system which provides a unified platform (Shi et al., 2014)	Promote energy management contracting by industry associations.(Shi et al., 2014)
			Voluntary building certification programs such as LEED(Matisoff et al., 2016)	Expedited permitting(Onuoha et al., 2018)
			Density bonuses or gross floor area (Sentman et al., 2008)(Onuoha et al., 2018)(Qian et al., 2016)	Efficient legal frameworks(Azeem et al., 2017)
			Public Utility Credit(Taemthong and Chaisaard, 2008)	
		Financial	Green tax exemptions (Joachim et al., 2017)	Low stamp duties(Joachim et al., 2017)
			Discounts (Joachim et al., 2017)	Increases developers' property tax(Onuoha et al., 2018)
			Loans or grants(Joachim et al., 2017) (Onuoha et al., 2018)	Decrease government property tax revenue(Onuoha et al., 2018)
			Market-based incentives such as characterizing water consumption by market segment (Grosskopf and Kibert, 2006)	Sales Tax Remittance for Clean Technology Purchases(Taemthong and Chaisaard, 2008)
			Transferable Energy Tax Credit(Taemthong and Chaisaard, 2008)	
			Green tax exemptions(Joachim et al., 2017)	
	Negative Incentives		Requiring certain private and public developments to meet specific green building standards(Sentman et al., 2008)	Retrofit existing buildings(Shi et al., 2014) (Onat et al., 2014)
			Regulating carbon output(Cidell and Cope, 2014)	Pollution tax(Shi et al., 2014)(Onuoha et al., 2018)

4. DISCUSSION

In this study, the top 10 journals on GBC policies were ranked by Histcite software based on the number of articles and their citations. Afterward, a summary of comprehensive knowledge management was provided through analyzing the research keywords and timeline co-occurrence network by VOSviewer software. Then, a cluster analysis and burst detection method were accomplished using the CiteSpace software. Clusters could be an interpretation of the major path taken in the GBC policy fields. Subsequently, most pioneer countries in this research

were identified. China was placed at the top of the list, followed by the USA and Australia in the second and third places, respectively. In this study, the "hot" articles having the most citations in green building policies from 1990 to 2019 were identified. Also, the top 10 most cited articles were determined separately for each year. Fluctuations in the citations over the years have well-illustrated the large attention paid to different parts of the relevant topics, which have been changed depending on the circumstances and concerns over time.

All research data was limited to the WoS database and therefore can be complemented in future studies by using other databases like the ProQuest Research library, Academic Search Complete, Scopus, etc. The research keywords were limited to a specific domain of GBC policies, to cover the title; consequently, future studies can be conducted in a wider domain of keywords. A further limitation of this study was limiting the publication record to three decades.

5. CONCLUSION

This study conducted a systematic review of published journal articles from 1990 to 2019. Nienty-five selected articles on the policies, incentives, and barriers related to GBC policies were derived from the WoS database, and then analyzed using Histcite, CiteSpace, and VOSviewer software. The findings showed that the H-Index criteria, and Impact Factor alone cannot be reasonable parameters for adopting the top journals in this field, because these indexes only demonstrate the total number of articles published in journals. The interpretation of research clusters could indicate the main points of green building policy issues and areas prone to show the development of this industry. Studies on "performing leadership," "developing status," "states construction industry" with high frequency of conducted papers emphasizes the industry needs and popularity of these areas on GBC. The high number of studies reveals the importance and the ever increasing interest of these areas to researchers. By categorizing published articles on GBC, it is possible offer researchers new directions for more detailed future research.

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