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Review

Visualisation of High-Density City Research Evolution, Trends, and Outlook in the 21st Century

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Abstract: High-density cities are growing in number and importance due to globalisation, significantly contributing to local, regional, and worldwide economies. It is progressively becoming clear that the high-density features of cities are associated with the frequency of disasters. As more than half of the world's population currently resides in cities, the study of high-density cities is evolving into an academic topic. In this study, the WoSCC (Web of Science Core Collection) and CiteSpace software were used to visualise and analyse the development history, current status, hotspots, and trends in high-density city research. We analysed a total of 377 valid articles spanning 2001 to 2022. This research aimed to illustrate the trajectory of high-density city development and to summarise the field's research hotspots and development history after entering the 21st century. It is hoped that this study will provide a theoretical reference and development direction for the future development of the field of high-density city research. Our results indicate that more publications have used the relevant keywords over time and that the research has overall trended from general to specific, noticeably changing in response to urban modernisation. Academic study in this area is still in its early stage. Instead of an inherent urge to spontaneously advance due to academic output, the research field has primarily grown in response to urban problems. COVID-19 has also hastened urban infill, further impacting existing high-density communities' urban environments, transportation infrastructure, and economies. The global epidemic has added urgency to research on high-density cities, and new content and directions are being developed. Assessing the hazards of high urban density while maximising its economic role is a significant part of academic research on high-density cities at this stage and will remain so in the future.

Keywords: bibliometric analysis; CFD simulation; CiteSpace; COVID-19; high-density cities; high-density city; literature review; progress and prospects; public healthy; sustainability; urban strategy

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1. Introduction

1.1. Literature Review of High-Density Cities

1.1.1. Origin of Modern High-Density Cities

Since the first Industrial Revolution, population, capital, and industries have centralised and converged in cities to produce enormous economic benefits [1,2]. This is due to the rapid iteration of production methods, the impact of enormous technological innovations, the drive of commercial interests, and the objective requirements of industrial production activities. The labour force, production resources, production space, and trade space needed for industrial operation transformed urban spaces into continually expanding, centralised economic production activity areas, leading to a relatively high physical density of urban development [3,4]. Consequently, a modern, high-density city started to emerge.

The average percentage of people living in urban areas reached 30% in 1950 [5]. At the same time, governments were starting to understand that economic production was essential to a country's development and position in the international arena due

to increased global exchanges and collaboration [6]. Furthermore, throughout recorded history, high-density cities have been shown to be the most advantageous urban shape for productive activity. As we entered the 21st century, high-density cities began to proliferate worldwide due to the globalisation of economic transactions [7,8]. A current focus of city research is achieving high-quality economic development and more suitable human living environments in cities by determining the best path for high-density city development based on the national conditions of each country.

1.1.2. Awareness of High-Density Cities

Architectural, or urban, density emerged in Europe in the 19th century. Urban planners started to consider the effects of the quickly expanding Industrial Revolution, which resulted in population congestion, dense housing and workplaces, and accompanying filthy urban landscapes of sickness, crime, and social exploitation [9,10]. The history of urban growth reveals the two sides of high-density cities. On the one hand, high-density construction allows cities to concentrate on their necessary production conditions, as the agglomeration effect of centralised cities enhances the rate of urban construction and production efficiency [11]. As more labour and resources are required for financial operations, a core region grows to include adjacent areas. To meet the demands of a nation's rapid development, the region expands into a centre-agglomerated city at a high development speed. In the meantime, economic production activities make it feasible to modernise the city's infrastructure, including healthcare, education, community facilities, and public transportation. This also improves people's quality of life and helps them understand their value [12].

On the other hand, high-density development is also accompanied by issues such as overcrowding, the failure of spatial functions to meet residents' needs, chaos in transportation space systems, a lack of natural landscapes, the emergence of epidemic diseases, and issues with residents' mental health [13]. Furthermore, the ongoing occurrence of highly industrial production activities, excessive exploitation of urban resources, and excessive anthropogenic damage to the urban environment make urban systems unstable and significantly jeopardise economic progress and the natural environment. Recent signs of instability in high-density urban systems include the thermal island effect, the rise of fluid diseases, and the emergence of extreme weather [14]. Additionally, as a result of economic and social advancement, urban planners are now studying people's psychological states and treating them as their primary focus, and liveable cities have gradually become the construction goals of various high-density cities [15].

Urban experts have therefore seriously considered the two-sided nature of high-density cities, which has led to a state of content entanglement and interplay in this research field. Since the advent of industrialisation, academics have been investigating how to balance the positive and negative aspects of high-density urban development to preserve sustainable urban development and build liveable cities. This research was based on the enormous economic production potential of high-density cities and their attributes that are closely linked to human survival.

1.1.3. Exploring the Development Process of High-Density Cities

The definition of high-density cities was the initial focus of this research. What exactly is a "high-density city"? What aspect of the "high density" of a city significantly impacts it? First, academic studies have attempted to describe "high density" using the physical definition of density, such as the ratio of building area, building height, open space, and building coverage to the metropolitan area. However, this definition does not reflect the negative implications of high-density cities, and the ratio does not judge the quality of high-density city construction. This is because the development of a high-density metropolis requires the consideration of several variables, such as economic and productive activity characteristics, the direction of urban risk prediction, residential travel patterns, and the psychological makeup of the city's inhabitants [16,17].

Furthermore, the term "high density" cannot be philosophically equated with simple proportions because urban buildings vary in form, openness, construction materials, and combination [18]. In addition to the buildings themselves, urban green spaces, among other spaces, are included in the judgment of the quality of high-density cities. At this stage, the international academic community mainly uses population and building density to make preliminary judgments and definitions of high-density cities [19]. The accepted judgment of a high-density city is whether it is economically and developmentally efficient enough to achieve the highest possible density while maintaining a state of relative physical and psychological comfort.

The definition of high-density cities implies the scope of the field of study. It includes not only the physical dimension but also social and human factors. The feedback mechanism between subjects is unclear, and various evaluation systems are still being developed, which has contributed to the difficulty of defining the concept of a high-density city [20]. Hence, accurately defining or judging the quality of high-density cities will take a long time and depend on the innovative research and discoveries of academics in this field.

1.1.4. Review of the Literature on High-Density Cities

Since the internal feedback mechanism of high-density cities is not clear to academics, the main research approach at this stage is to summarise historical experiences and observe the impacts of high-density city construction behaviour [21]. There are two main directions for high-density city research at this stage: (1) "optimal utilisation" is used to maximise the economic benefits of high-density cities using relative urban resources; (2) "alleviating problems" is used to address issues that threaten the balance of urban development and improve the affordability of urban systems [22–24].

Global researchers have produced many theories on the optimal utilisation of high-density city development. In the 1980s and 1990s, due to the relatively limited resources of cities, urban researchers and planners pointed out that urban development was not about sprawl and uncontrolled population introduction but about maintaining a certain degree of urban density [25]. Many classical urban theories have been proposed to maximise the clustering role of high-density cities, e.g., the "compact city", "smart growth", and "TOD" theories [26,27]. These theories focus on urban systems, examining their components and linkages, internal feedback mechanisms, and the best ways to use their limited resources. They provide a theoretical basis for the development of high-density cities around the world. Additionally, academic researchers are now investigating and comparing the relationship between the spatial form of different cities and the degree of economic development and modernisation in the international arena [28].

Scholars in the 21st century have used digital technology and the theoretical foundation built by previous academics to further research in different directions, including energy conversion, land use, public transportation, public infrastructure, high-rise building construction, and functional compounding, in order to rationalise the use of urban resources [29,30]. However, these directions have only been used to summarise laws and prove their relevance. Academic researchers have not conducted systematic and in-depth research in these areas.

Most developing countries worldwide are experiencing the rapid transformation of agglomerative cities due to the technological impact of recent technological innovations. Moreover, due to different national conditions, inadequate upfront planning and unlimited expansion and concentration have posed many urban problems for global cities [31]. As the adverse effects of high-density cities began to take hold, people began to understand the negative impacts of the construction process on the urban economy and human habitats, especially those in developing countries. Since the beginning of the 21st century, the problems caused by high-density cities have begun to radiate globally due to increasing international urban expansion [32]. All of humanity is facing a huge survival and development crisis.

The problems associated with high-density city development are mainly related to urban construction and urban residents' physical and mental problems [33]. Urban con-

struction problems include issues in urban land use, energy, transportation, construction, and environment due to insufficient or inexperienced pre-planning, such as landscape fragmentation, abandonment, pollution, and traffic chaos [32–35]. Further problems include the global and regional disasters caused by overuse and irrational use, such as pollutant overload, global warming, the heat island effect, extreme weather, and uncontrollable epidemics; epidemics are the current primary threat to human existence and need to be taken seriously. The physical and mental problems of urban residents are caused by the impact of high-density urban construction on human living spaces, such as the "oppressive feeling" of neighbourhood height-to-width ratios and a lack of green space, causing psychological depression in urban residents. A lack of public space leads to sub-optimal health outcomes for urban residents, a lack of desire for interaction, and other psychological problems [34].

These problems affect the balance of an urban system, destroy the limited resources of a city, limit the development of economic and productive activities, and hinder the construction of the human environment in a city [35]. International academic researchers have attempted to address these problems in several ways to ensure sustainable urban development. The development of digital technology, building technology, clean materials, and energy sources has brought new ideas to solve urban problems from the perspective of urban material circulation and new possibilities to predict and solve urban hazards. The problem-solving process has also led academic researchers to understand the enormous impact of the natural environment on high-density cities [36]. Scholars have recognised the important role of green space in urban disaster resolution, and the construction of landscape garden cities is considered to be an effective measure in building urban safety patterns. Urban daylighting and temperature have also become the focus of research in high-density cities because of their relevance to people's lives [37]. Moreover, the study of people's living conditions has also gained prominence in this discipline due to the advancement of ideas brought on by economic prosperity. Currently, researchers are concentrating on the creation of urban public spaces that are environmentally friendly and the psychological reactions and behavioural adjustments of persons involved in urban development [38]. As the development of high-density cities inevitably moves forward, researchers have begun to study the use of space in cities and to determine how to integrate mitigation measures with urban construction [39]. Efforts have also been made to study each element's impact and establish an evaluation system to ensure the sustainable development of high-density cities.

1.2. Justification of This Research

1.2.1. Current Status and Dilemmas of High-Density City Research

We analysed data from the United Nations Department of Economic and Social Affairs and the World Population Network and reached the following conclusions. (1) As of 12 November 2020, the total population of 230 countries in the world exceeded 7.5 billion, with about 55% of the population living in cities. (2) In 2050, the global population is expected to exceed 9 billion, and 68% of the population will live in cities [40–42]. In the 21st century, the development of high-density cities has and will continue to affect everyone worldwide.

Global cities are typical positive representatives of high-density cities, as they often have large populations, significant international influence, and complex material flows [43]. The construction of these cities is often self-sufficient and has served as an important reference for the construction of high-density cities around the world. Cities such as London, Paris, and Madrid have a balanced distribution, while cities such as New York, Hong Kong, Tokyo, and Sao Paulo are clustered and polycentric. Despite their different forms, however, these cities have high degrees of stability and dynamism. However, these global cities are suffering from multidimensional hazards associated with high-density features, including natural disasters, urban hazards, ecological safety, and the growing psychological problems of people.

In retrospect, research on high-density cities is still at an early stage due to a lack of awareness and experience [44–46]. For instance, some initial studies did not consider the negative impacts of high-density cities because of different research purposes. For

instance, in the earliest studies on urban flooding, the link between hazards and high urban density was not fully recognised. Academic researchers are still unable to reach a consensus on the definition of a high-density city. They cannot find a feasible density concept to credibly judge the future state and forms of buildings and cities or to evaluate the balanced relationship between construction and development, urban facilities, and other factors [47,48]. The fundamental reason for this is that academic researchers are unable to comprehensively summarise the specific contents contained in the vast field of high-density cities and determine which subjects play decisive roles in the concept of high density under urban construction. Therefore, the definition of high-density cities requires a further search for influencing factors.

The demands of modernisation and economic development in various countries have forced academic researchers to study high-density cities from the perspectives of economic and commercial activities [49]. Current mainstream academic research is attempting to study how to rationalise the use of urban resources from the perspective of urban resources to achieve maximum economic benefits. It is more oriented towards the conceptualisation and correlation analyses of qualitative directions based on historical urban experiences. Therefore, it generally lacks precision and universality, cannot be applied to the construction of high-density cities in different countries under different conditions, and mostly contributes directional references.

Although its definition and internal feedback mechanisms are unclear, the disasters caused by high-density urban construction need to be urgently addressed. At this time, academic research on urban disasters has focused on specific disaster solutions, such as using green space to improve the urban heat island effect and changing urban building forms to improve airflow. The researchers' main purpose is to reduce the occurrence of disasters [50]. However, the currently understood mechanisms of disasters are not precise enough, and their hazard potential for a city cannot be judged if they remain at the level of salvage and remediation. Research on urban problem solving also suffers from further economic progress and insufficient correlations, such as regarding the simulation of urban wind flow in the quantitative research stage of software simulation [51]; the field also tends not to link these characteristics. The current research phase is focused on solving and preventing the problems and disasters arising in high-density cities by using land resources to maximise economic production and improve the living environment [46].

This review of the current dilemmas in this field has revealed that high-density urban research has been hindered by the fractured development and fragmentation of the subject matter. Since a city is itself a system, neither the development of a city nor the solution to urban problems can be achieved by working in a single research direction. Researchers should focus on mutual complements and references, breakthrough points, and difficulties in different research areas over different time periods, and this focus will be aided by the knowledge mapping of time changes with a clear representation of content and connections.

1.2.2. Aim of This Study

Currently, the study of each aspect of high-density cities is at a superficial correlation research stage. Proper evaluation systems and research techniques have not been determined, the connections between each aspect remain unclear, and the theoretical system is not systematic. However, due to the great significance of high-density urban construction for human development and survival, a systemic understanding of this research area is urgently needed [52]. Furthermore, the COVID-19 outbreak reinforced the need for research on high-density cities, as the epidemic's highly contagious and dangerous nature appears to be more intense in high-density cities [53].

Based on the development history and current status of high-density city research, this study aimed to use metrology and visualisation tools to produce a knowledge map of high-density cities. With the advancement and development of software and networking technologies, bibliometric methods have been used for statistical and analytical purposes in different subject areas [54]. These methods are also integrated, comprehensive, and

visualised, which have been utilised in a variety of fields and have produced relevant results [55,56]. Most importantly, they facilitate the mining of potential knowledge in the literature data from a more objective perspective: structure, patterns, distribution, etc. [57].

Therefore, based on bibliometric analysis, we present the basic elements of the research field and summarise the urban hotspots at each stage of high-density urban development. This study's results are intended to enable academic researchers to conceptually deepen and broaden the boundaries of high-density urban research, as well as to aid in understanding the connections between various research components so that it will become possible to summarise and compare various research methods and predict the future behaviours of high-density cities. This will enable academic researchers to grasp the pulse of research development, summarise research results, and better guide high-density urban development.

1.2.3. Structure of This Study

This paper is divided into three parts. The first part introduces the data sources and research methods. The second part reviews the research progress in high-density cities based on the data of published papers, including trends in publication volume, the distribution of publication journals, the distribution of publication region cooperation, the distribution of published authors, and the distribution of research institution cooperation. Finally, the third part presents a research keyword analysis and summarises the hotspots and prospects of high-density city research.

2. Materials and Methods

2.1. Data Sources

The first step of this study was to select reliable and recognised journal articles using WoSCC. WoSCC is one of the most comprehensive databases of academic journals in the international academic community; it contains the most comprehensive research results from all over the world and has timely updates and authoritative data. To ensure the study's rigour, we initially set restrictions on data selection [58].

The second step was to determine the search keywords and filtering scope. There is currently no formal definition of high-density cities, and the terms "high-density city" and "high-density cities" are commonly used in this field of study by default. Therefore, we searched the WoSCC for the "high-density city", "high-density cities", "high-density city", and "high-density cities" keywords. Then, we selected "Topic" as the retrieval type so that our database search included titles, abstracts, and keywords. This research used the special session of the General Assembly for an overall review and appraisal of the implementation of the Habitat Agenda, conducted by the United Nations in New York in 2001, as the search's starting point, and the screening period was set from 2001 to 2022 [59]. A total of 397 articles were retrieved. After importing CiteSpace.v.6.1.R2 and removing duplicate and conference articles, 377 papers were exported and used as raw data.

2.2. Research Methods

Knowledge mapping is a common method in bibliometrics and the main method used in this study. It is possible to synthesise a large amount of content and visually express the results of the quantitative analysis of subject knowledge in visual form. Many existing knowledge mapping analysis tools currently exist, among which CiteSpace is widely used [60]. CiteSpace is software for visual analysis based on the Java platform, presenting the structure, laws, and distribution of scientific knowledge through visual analysis [61]. This study was conducted to visualise research trends and form knowledge maps using journal data through CiteSpace.v.6.1.R2. Therefore, this study is systematic, graphical, and pulsed [62].

In this research, the study data interval was set from 2001 to 2022 because academics began to actively publish scholarly results in this field during that event. Through CiteSpace.v.6.1R2, information about the target journals, such as keywords, topics, authors, years, and institutions, were extracted and analysed as network nodes. The information from the

target journals was pooled and quantifiably considered to form graphical relationships. The temporal frequency of each node and the association between each node can be clearly shown in the graphical relationship, thus reflecting the current research situation and the interconnection of each node [63].

This study also used the measurement tool in CiteSpace.v.6.1.R2 to perform a cluster analysis to measure the similarity between different keywords and to classify keywords into different group classes [64]. This allowed us to understand the frame of and specific research directions for studying high-density cities [65]. We used temporal parameters in the CiteSpace.v.6.1.R2 analysis to describe the field's research hotspots and development history and to forecast and suggest references for future development. The specific research route is shown in Figure 1.

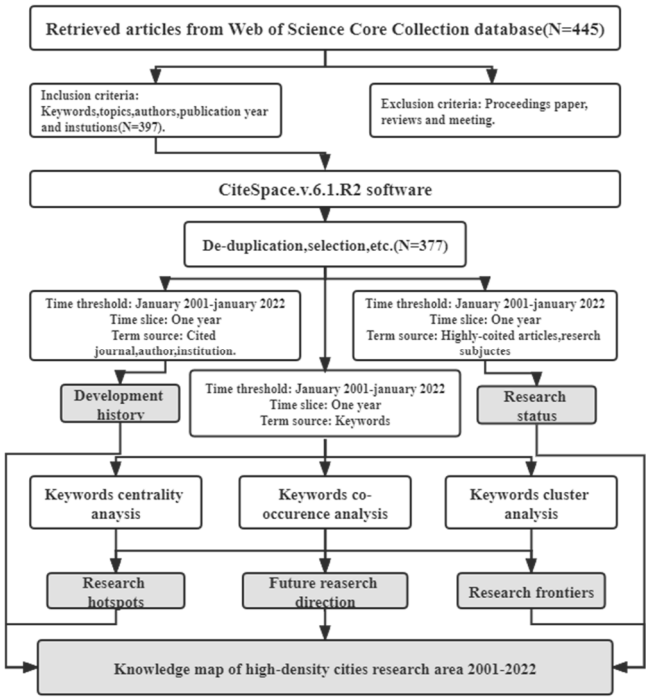

Figure 1. Outline of high-density city research design.

3. Results

3.1. Review of Research Progress

Due to the expansion of the global economy and modernisation, high-density cities have been established worldwide and have become the major urban trend in various countries [66]. In the 21st century, the United Nations and several countries have jointly issued initiatives, such as those described in Table 1, to bring attention to the worldwide impact of high-density cities on sustainable and economic development [67,68].

Table 1. High-density city-related initiatives.

Publisher	Name	Release Time	Focus
United Nations	The Millennium Declaration	September 2000	Protection of the typical environment; increased cooperation to reduce the number and impact of natural and artificial disasters
United Nations	Special Session of the General Assembly on Habitat: Istanbul + 5 6–8 June 2001, New York	June 2001	Adequate shelter for all and sustainable human settlement development; sustainable cities
World Summit on Sustainable Development	Johannesburg for Sustainable Development	September 2002	Sustainability; social development to meet the needs of each individual; climate and energy
United Nations	New Urban Agenda	October 2016	Sustainable urban development; cities, human settlements, and sustainable civic development

3.2. Results by Data Collection

3.2.1. Publication Trends in This Area

The trends regarding the number of academic publications were found to reflect the historical development of high-density city research. Data for the target paper publication years were collected from WoSCC [69]. Figure 2 shows that the number of published papers on high-density city research has increased every year since 2001. From 2001 to 2006, the number of relevant research papers grew slowly or even stagnated, demonstrating that the concept of high-density cities had not been accurately defined and had become a popular research field. From 2007 to 2014, the number of research papers in this field increased, indicating increased academic interest. From 2015 to 2022, the number of research papers in this field rapidly increased, with the highest annual production of 89 papers and the highest average annual growth rate overall, indicating that this field has begun to receive attention from the academic community.

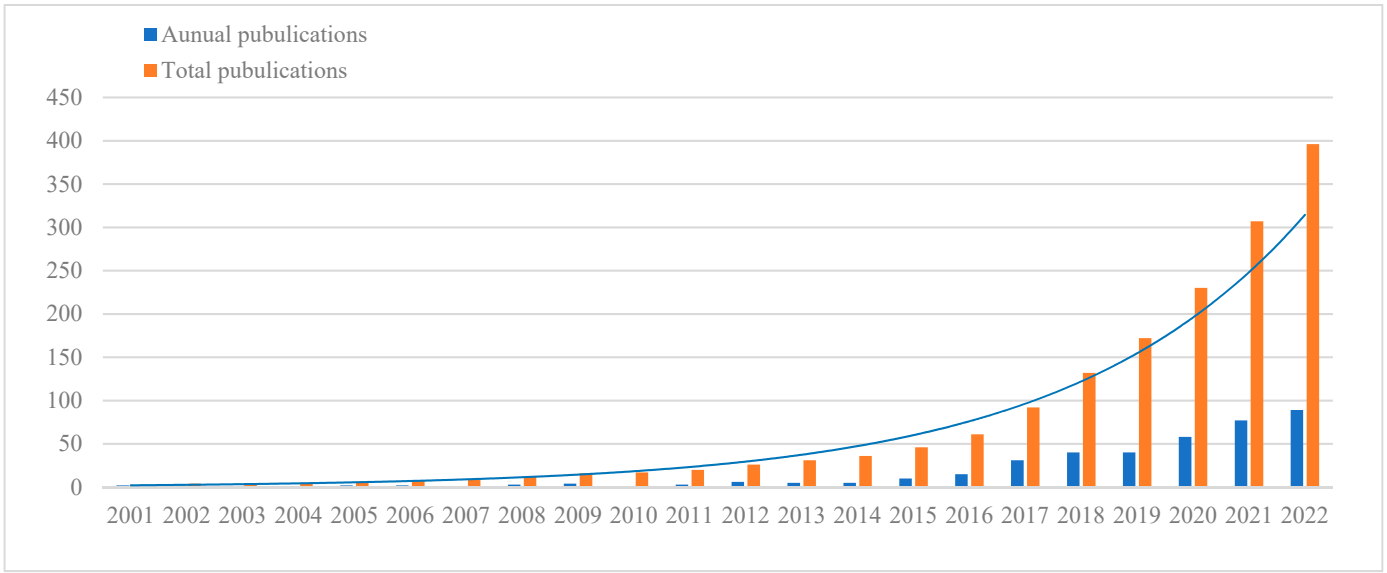

Figure 2. Publications on high-density city research from 2001 to 2022.

High-density city research quickly developed into an academic research hotspot in just 20 years, indicating the tremendous necessity of studying this field at the current stage

of human development. According to publication volume trends from 2001 to 2022, this research topic will continue to be a major area of academic focus.

3.2.2. Cited Journals

Cited journals were considered to reflect hot research directions in the field of high-density cities. Setting the node to cited journals and the time slice to 1 year yielded a joint map of cited journals. In Figure 3, the relative number of publications in the target journals is represented by the size of the circles. The size of the outer outline of a circle represents the degree of centrality and impact. Table 2 was created by organising the software data. Frequency represents the number of citations, and centrality represents the impact of journals in the field. According to the frequency of citations, the top three most cited items were Buildings and Environment (198), Landscape and Urban Planning (173), and Energy and Buildings (128).

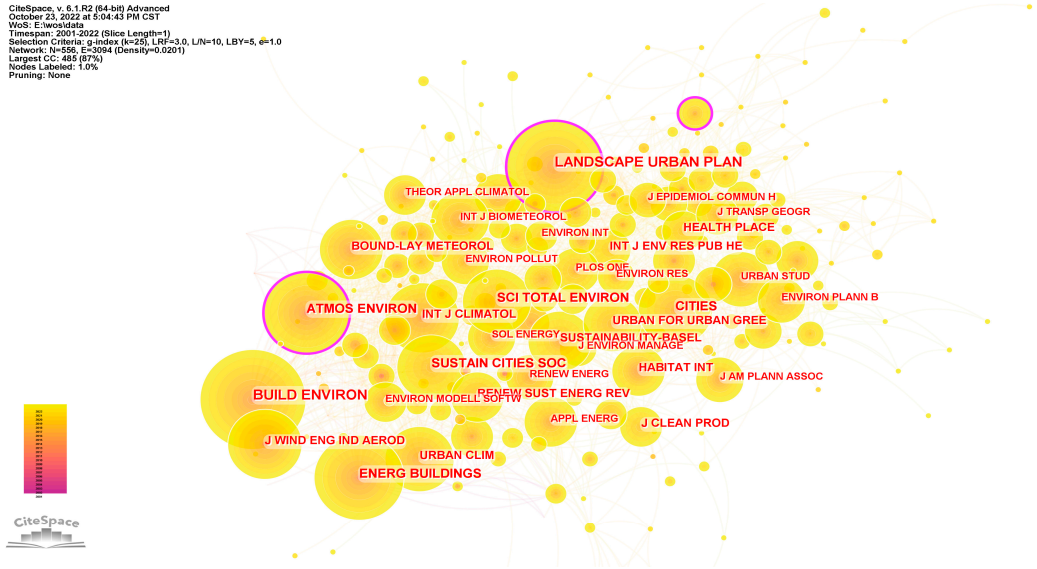

Figure 3. Knowledge map of co-journals of papers published in high-density cities from 2001 to 2022.

Table 2. Major cited journals in the field of high-density cities from 2001 to 2022.

No.	Freq.	Centrality	Cited Journals	ISSN	Country	First Cited Year
1	198	0..07	Building and Environment	0360-1323	England	2005
2	173	0.15	Landscape and Urban Planning	0169-2046	The Netherlands	2006
3	128	0.05	Energy and Buildings	0378-7788	Switzerland	2001
4	122	0.11	Atmospheric Environment	1352-2310	England	2008
5	112	0.03	Science of the Total Environment	0048-9697	The Netherlands	2015
6	107	0.02	Sustainable Cities and Society	2210-6707	The Netherlands	2016
7	94	0.07	Cites	0264-2751	England	2008
8	85	0.03	Journal of Wind Engineering and Industrial Aerodynamics	0167-6105	The Netherlands	2012
9	80	0.03	Sustainability	2071-1050	Switzerland	2009
10	79	0.05	International Journal of Climatology	0899-8418	England	2016

The top ten most-cited journals reflected the main research areas of construction building technology, architecture, environment, urban studies, meteorology, geography, public health, and sustainable society. Most of the articles were also published in journals with high impact factors, indicating that the research field is recognised and focused on by the high-density urban academic community.

3.2.3. Distribution of Cooperation by Region of Publication

We created a knowledge map of cooperation regions to develop a list of major countries with high-density cities and their cooperation relations. Setting the node to country and the time slice to 1 year yielded a joint map of the distribution of different countries with high-density city topics; see Figure 4. Moreover, Table 3 was created by organising the software data. Regarding posting frequency, the top three countries were China, the United States, and Singapore, followed by Australia, the United Kingdom, and South Korea.

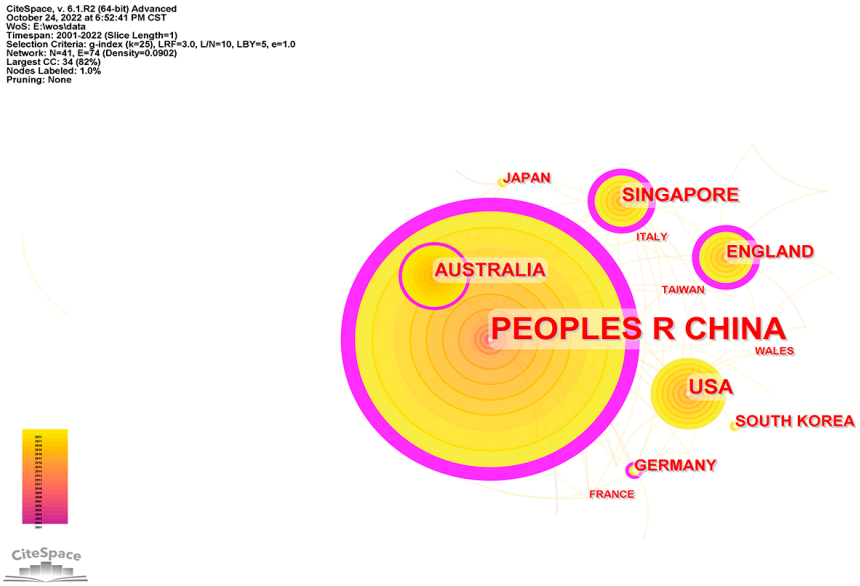

Figure 4. Knowledge map of regions most contributing to high-density city research from 2001 to 2022.

Table 3. Regions most contributing to high-density city research from 2001 to 2022.

No.	Country	Number of Articles	Centrality	Year of First Publication
1	China	270	0.73	2001
2	USA	33	0.1	2014
3	Singapore	31	0.27	2005
4	Australia	29	0.12	2002
5	England	21	0.24	2002
6	South Korea	15	0	2006
7	Germany	14	0.18	2012
8	Japan	11	0.08	2009
9	France	6	0.08	2017
10	Wales	5	0.02	2018

The main study countries were found to be mainly economically developed and developing Asian countries actively pursuing economic development, as these countries began researching this subject earlier than the others. Additionally, the more nations are interested in studying economic growth, the more pressing is the demand for such growth. Furthermore, it is evident from the findings that there is international interchange and collaboration, although economic and other external factors influence these processes. The research agendas of nations at various levels of development were found to have different focuses.

3.2.4. Distribution of Authorship of Articles

The analysis of co-authors was used to determine the current status of contributing authors, the directions of the research topic, and the collaborative relationships among

scholars in high-density city research, as presented in Figure 5. The circle size represents the frequency of postings, and the thickness of the outer purple circle represents the degree of association among the authors. The lead authors, in order of frequency of publication, were found to be Ng, Enoch (39); Lau, Kevin Ka-lun (27); Ren Chao (21); and Shi Yuan (18). Figure 5 shows that there are currently few researchers and scholars in high-density city research, and the overall state is fragmented. The amount of contribution from the core figures was shown to be prominent and concentrated. Table 4 presents information on the leading authors of high-density city research, including their main research areas.

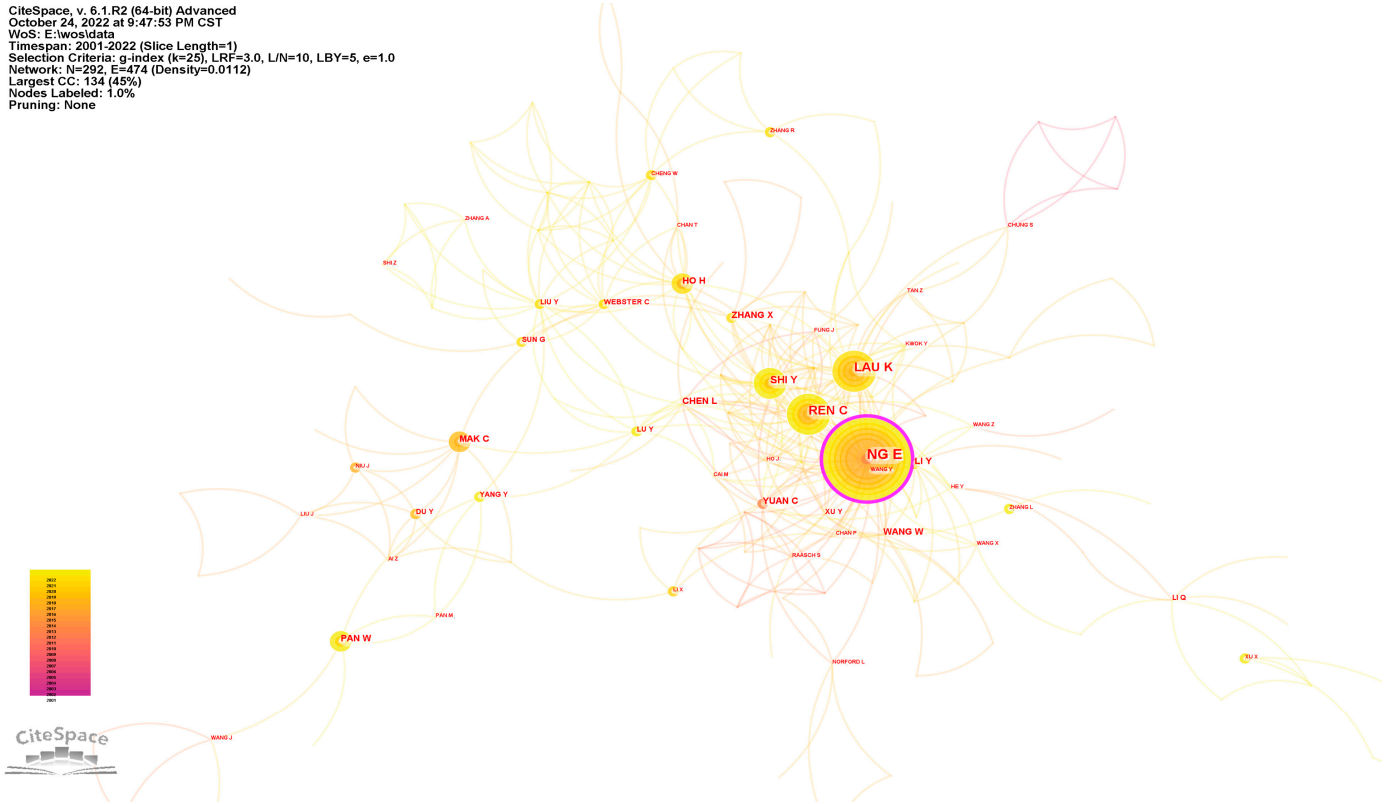

Figure 5. Knowledge map of the major authors of high-density city research from 2001 to 2022.

Table 4. Major authors of high-density city research from 2001 to 2022.

No.	Publications	Centrality	Year	Author	Country	Main Subject Categories
1	39	0.13	2008	Ng, Enoch	China	Construction and Building Technology
2	27	0.05	2013	Lau, Kevin Ka-lun	China	Construction and Building Technology
3	21	0.05	2011	Ren, Chao	China	Environmental Sciences and Ecology
4	18	0.05	2016	Shi, Yuan	China	Environmental Sciences and Ecology
5	12	0.04	2011	Yuan, Chao	Singapore	Science and Technology
6	12	0.04	2017	Mak, Cheuk Ming	China	Engineering
7	9	0.06	2011	Chen, Liang	China	Engineering
8	9	0.08	2017	Ho, Huang Chak	China	Environmental Sciences and Ecology
9	9	0.03	2020	Pan, Wei	China	Environmental Sciences and Ecology
10	8	0.01	2015	Li, Yu Guo	China	Engineering

We found that there was little cooperation among the researchers and a lack of teams with core leadership in this research field. Additionally, the number of contributions from core individuals was found to be outstanding and concentrated.

3.2.5. Distribution of Research Institute Cooperation

The analysis of collaborative relationships among research institutions was used to gather insight into the sources of academic support, regional support, and collaborative relationships among institutions in high-density urban research. Setting the node to institutions and the time slice to 1 year yielded a joint knowledge map of high-density urban research institutions and collaborations; see Figure 6. Table 5 as created by collating the software data. The top three major publishers ranked according to the frequency of publication were Univ Hong Kong (85), Chinese Univ Hong Kong (69), and Hong Kong Polytech Univ (42). The top three major publishers ranked according to centrality were Univ Hong Kong (0.34), Chinese Univ Hong Kong (0.19), and City Univ Hong Kong (0.16). The knowledge map shows that the research institutions in the field of high-density cities were geographically concentrated, with more research conducted at universities, thus indicating that the field has not yet received significant attention from general society.

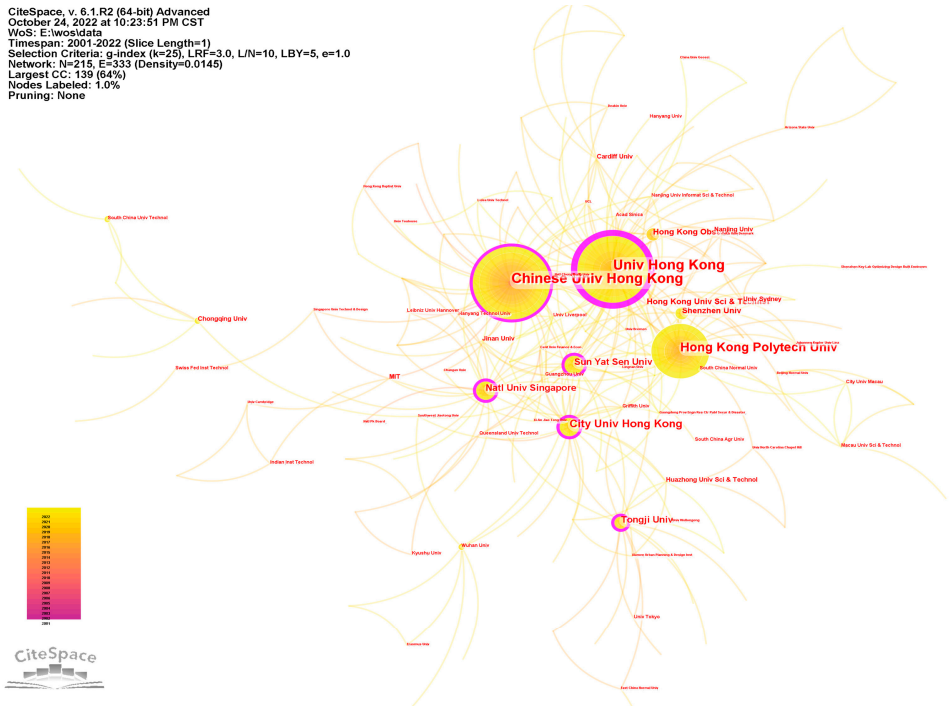

Figure 6. Knowledge map of major institutions in the research field of high-density cities from 2001 to 2022.

Table 5. Major institutions in the research field of high-density cities from 2001 to 2022.

No.	Freq.	Year	Institution
1	84	2001	The University of Hong Kong
2	69	2008	The Chinese University of Hong Kong
3	42	2008	The Hong Kong Polytechnic University
4	23	2009	City University of Hong Kong
5	20	2005	National University of Singapore
6	17	2016	Tongji University
7	16	2018	Sun Yat Sen University
8	12	2017	Shenzhen University
9	9	2011	Hong Kong University of Science and Technology
10	9	2017	Hong Kong Observatory

The number of articles issued by research institutions was found to correspond to the degree of centrality, which indicates that influential institutions currently exist in this

field of research. However, the number of publications and the influence of each research institution need to be improved. Moreover, the centrality of each field institution in this research was found to be low and to show fragmentation, indicating that the cooperation relationship of each research field needs to be improved.

3.3. Research Areas

The main research categories in high-density city research were considered to reflect the research focus of the field. Setting the node to categories and the time slice to 1 year yielded a collaborative relationship graph of disciplinary categories, as shown in Figure 7. The size of the circles and the contours outside them in Figure 7 are relatively uniform, and there are more lines between them, indicating that high-density city research covers several well-connected areas. Current research areas were found to include architecture, the environment, engineering, urban design, and sustainable cities. Most research areas were established early, but some areas have emerged in recent years.

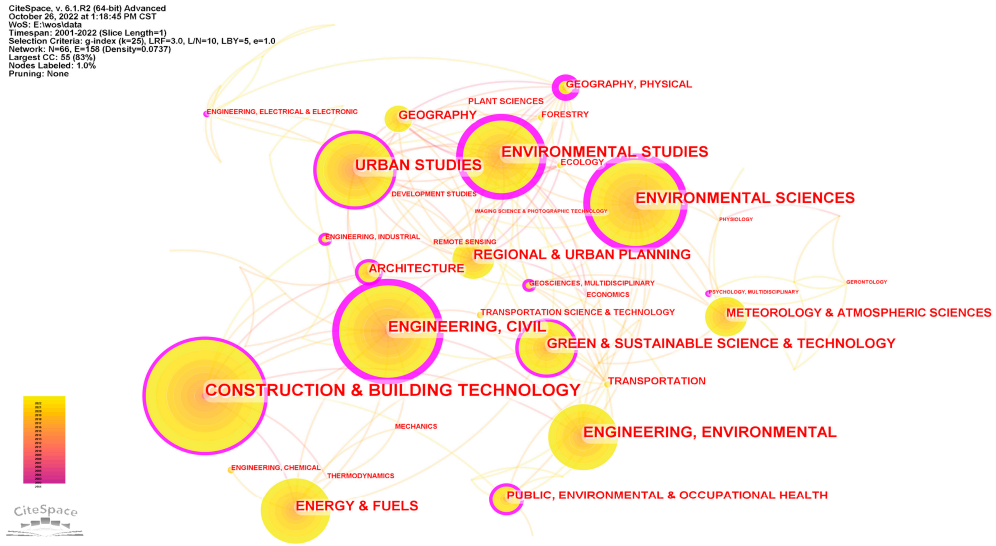

Figure 7. Knowledge map of major high-density city research categories from 2001 to 2022.

Table 6 was created using the software data. Ranked according to the frequency of publication, the top three major categories were Construction and Building Technology (106), Civil Engineering (85), and Engineering Sciences (76). Ranked according to centrality, Engineering Sciences (0.38) was the highest, followed by Environmental Studies (0.36) and Civil Engineering (0.27).

Table 6. Major high-density city research categories from 2001 to 2022.

No.	Freq.	Year	WoSCC Categories
1	106	2005	Construction and Building Technology
2	85	2005	Civil Engineering
3	76	2016	Engineering Sciences
4	66	2005	Environmental Studies
5	60	2005	Urban Studies
6	57	2009	Environmental Engineering
7	51	2001	Green and Sustainable Science and Technology
8	50	2001	Energy and Fuels
9	38	2005	Regional and Urban Planning
10	26	2005	Geography

Each research area in this field was found to be closely connected, cooperative, and in a cluster state. The authors were found to contribute to this research field from architectural engineering, environmental, and urban environmental perspectives, among others.

Our analysis of the research categories also showed that the frequency of articles did not correspond to centrality. For instance, despite having only five articles, the Electrical Engineering field showed a centre rate of 0.2. This result indicates that some journals with fewer articles may still contribute highly to the field.

Setting the node to reference and the time slice to 1 year yielded a knowledge graph of highly cited articles since 2001; see Figure 8. Table 7 was created by sorting articles according to citation frequency; the most-cited article was "Computational Fluid Dynamics for urban physics: Importance, scales, possibilities, limitations, and ten tips and tricks towards accurate and reliable simulations" (484), the second most-cited article was "CFD simulation of outdoor ventilation of generic urban configurations with different urban densities and equal and unequal street widths" (197), and the third most-cited article was "Pedestrian-level wind conditions around buildings: a review of wind-tunnel and CFD techniques and their accuracy for wind comfort assessment" (185). Of the first 30 most-cited articles, most concerned computer technology simulation research directions, such as wind flow line simulation and thermal comfort. The rest were related to the psychological problems of urban people.

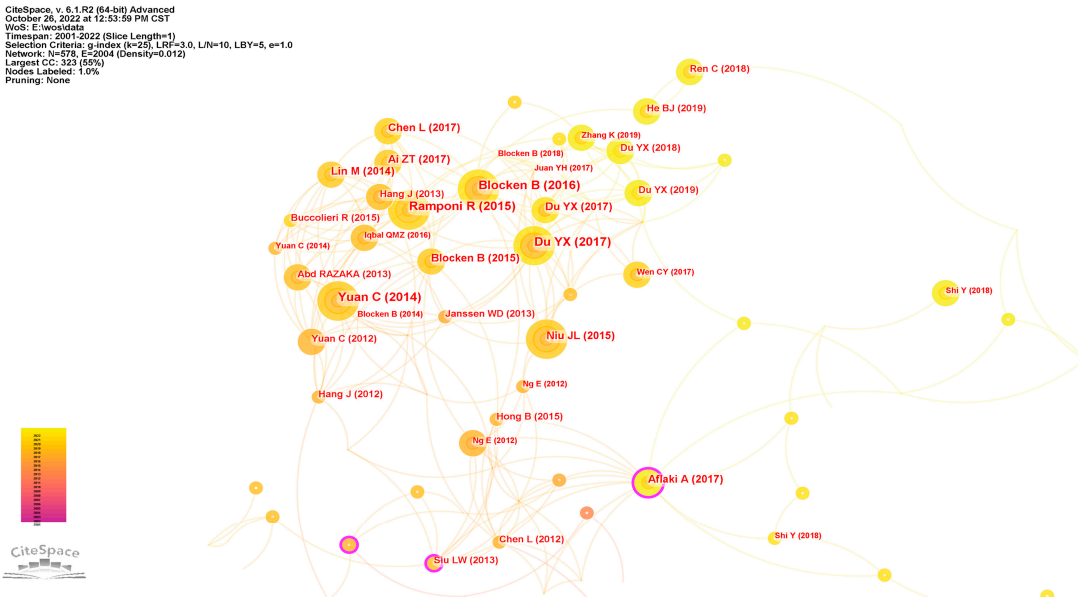

Figure 8. Knowledge map of highly cited articles in high-density city research from 2001 to 2022.

Table 7 also shows that the impact factor of each highly cited article was generally low and concentrated on a single technical level, indicating that researchers in this field are currently more inclined to use technology and research content for quantitative research. The other key research areas were still in their preliminary stages because there was no accepted research methodology and few highly cited articles.

We found that new research areas are emerging, indicating that this field is developing and progressing. However, we did not find any high-impact articles in this field, indicating that high-density urban research is still concentrated in groups. Each research field was found to be combined with others and to have mutual influence. Furthermore, due to the limitations of research methods, the research field was shown to focus mainly on the use of accepted research methods for specific areas and the improvement of research methods, and research in areas without accepted research methods showed a lack of influence and cooperation.

The expansion of the various directions of high-density city research over time demonstrates that the research field is being recognised and valued by society. However, the field is still in its early development stage. The results of each research direction cannot be effectively combined due to the lack of influence of each individual direction, resulting in the field's lack of overall influence and development power. However, by summarising the research hotspots in this field and studying their development directions, we can effectively predict future research directions and guide the development of this research field.

Table 7. Most-cited articles on high-density city research from 2001 to 2022.

No	Title	Times Cited	Publication Year	Research Area
1	Computational Fluid Dynamics for urban physics: Importance, scales, possibilities, limitations and ten tips and tricks towards accurate and reliable simulations	484	2015	Construction and Building Technology
2	CFD simulation of outdoor ventilation of generic urban configurations with different urban densities and equal and unequal street widths	197	2015	Construction and Building Technology
3	Pedestrian-level wind conditions around buildings: a review of wind-tunnel and CFD techniques and their accuracy for wind comfort assessment	185	2016	Construction and Building Technology
4	Improving air quality in high-density cities by understanding the relationship between air pollutant dispersion and urban morphologies	183	2017	Construction and Building Technology
5	Urban heat island mitigation strategies: A state-of-the-art review on Kuala Lumpur, Singapore and Hong Kong	157	2017	Urban Studies
6	Building porosity for better urban ventilation in high-density cities—a computational parametric study	136	2012	Construction and Building Technology
7	The impacts of building height variations and building packing densities on flow adjustment and city breathability in idealised urban models	112	2017	Construction and Building Technology
8	Enhancing urban ventilation performance through the development of precinct ventilation zones: A case study based on the Greater Sydney, Australia	112	2019	Construction and Building Technology
9	Quantitative ventilation assessments of idealised urban canopy layers with various urban layouts and the same building packing density	105	2014	Construction and Building Technology
10	A new method to assess spatial variations of outdoor thermal comfort: Onsite monitoring results and implications for precinct planning	103	2015	Construction and Building Technology

3.4. Research Hotspots and Research Strategies

3.4.1. Keyword Co-Occurrence Network

We analysed keywords to understand the focus of the studied research field. Setting the node to keywords and the time slice to 1 year yielded a knowledge graph of keywords used since 2001, as shown in Figure 9, where a larger circle represents a higher frequency of

keywords and a larger outer purple circle represents more connections with other keywords. The top 10 keywords, ranked according to frequency, are shown in Table 8.

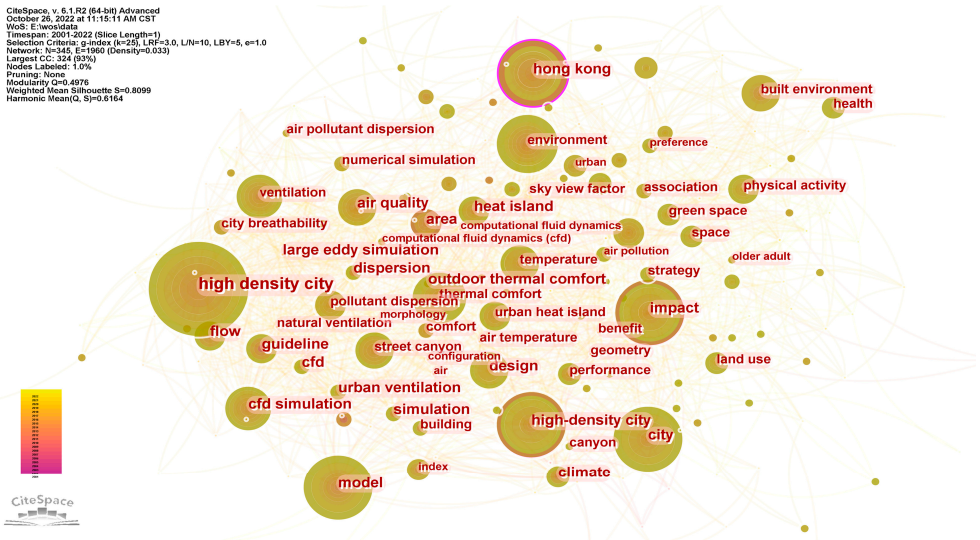

Figure 9. Knowledge map of major keywords in high-density city research from 2001 to 2022.

Table 8. Major keywords in high-density city research from 2001 to 2022.

No.	Freq.	Centrality	Year	Keywords
1	72	0.09	2015	High-density city
2	55	0.12	2009	Impact
3	53	0.10	2006	City
4	48	0.21	2005	Hong Kong
5	45	0.09	2011	Model
6	41	0.04	2015	Environment
7	38	0.01	2016	Thermal comfort
8	37	0.09	2009	Design
9	30	0.05	2012	CFD simulation
10	25	0.02	2012	Street canyon

The results showed that since 2001, people have become increasingly concerned about the impact of high-density cities, mainly in two respects. The first is the negative impact of high-density cities on the urban environment and people's physical and mental health, and the second is the better utilisation of urban resources; academia has paid more attention to the former than the latter.

3.4.2. Keyword Co-Occurrence Time Zone Analysis

The keywords were used to draw a time zone map, a character analysis method of CiteSpace.v.6.1.R2. The time zone keyword map was used to visually demonstrate each keyword's time, frequency, development trajectory, and derivative relationship to summarise emerging nodes and trajectories and to predict the field's research frontiers and development trends.

The analysis of the keyword time zone chart and software data (presented in Table 9 and Figure 10) showed that the development of high-density city fields could be divided into the following stages.

Table 9. The top seven high-frequency keywords in each period from 2001 to 2022.

Start-Up Period (2001–2006)				
No.	**Freq.**	**Centrality**	**Year**	**Keywords**
1	53	0.10	2006	City
2	48	0.21	2005	Hong Kong
3	2	0	2002	Attract radius model
4	2	0	2002	Lightning-strike incidence
5	1	0	2002	Lightning protection system positioning
6	1	0	2002	Tall structure
7	1	0	2005	Green architecture
Development Period (2007–2014)				
No.	**Freq.**	**Centrality**	**Year**	**Keywords**
1	55	0.13	2009	Impact
2	45	0.09	2011	Model
3	30	0.05	2012	CFD simulation
4	25	0.02	2012	Street canyon
5	23	0.08	2014	Built environment
6	23	0.02	2012	Temperature
7	21	0.02	2011	urban heat island
Accelerated Period (2015–Present)				
No.	**Freq.**	**Centrality**	**Year**	**Keywords**
1	41	0.04	2015	Environment
2	38	0.01	2016	Thermal comfort
3	25	0.03	2016	Ventilation
4	22	0.03	2016	Air quality
5	20	0.02	2018	Physical activity
6	18	0.01	2016	Flow
7	18	0.02	2019	Quality

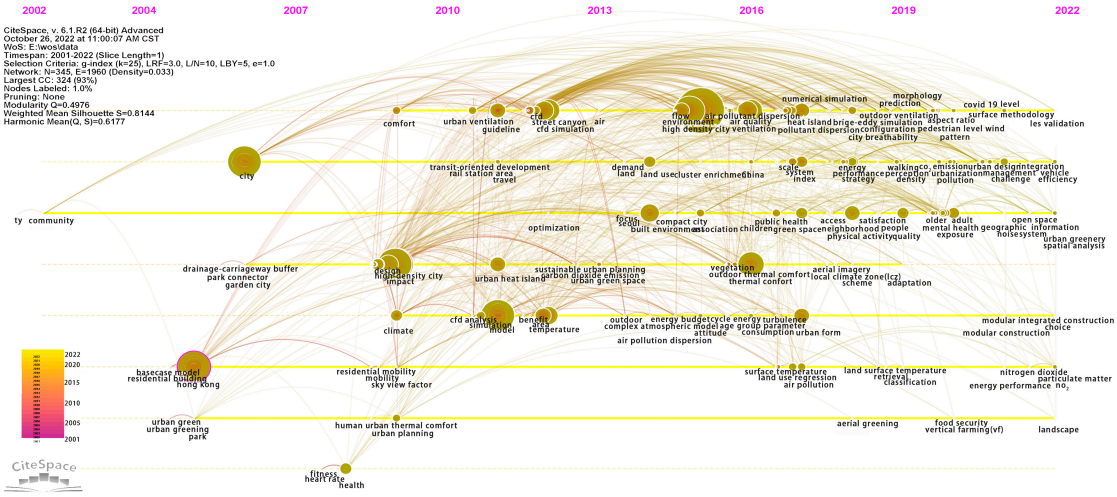

Figure 10. Co-occurrence time zones of high-density city research from 2001 to 2022.

1. Start-up period (2001–2006): The high-density city research field began. With the advent of the new century, global initiatives and globalisation have led to an awareness of high-density cities in various regions. However, research was limited by a lack of clarity regarding the definition of high-density cities and a lack of research awareness [70]. During this period, research in this field was relatively limited and slowly developed.

2. Development Period (2007–2014): This period was the development phase of high-density city research. As the influence of high-density cities globally expanded and the understanding of high-density cities became clearer, many small relevant topics, such as urban ventilation and carbon dioxide, emerged. Furthermore, there was by a growing awareness of the negative impacts of high-density cities and the need for sustainable cities. With advancements in computer software technology, research scholars have also started innovating research models to better study relevant problems [71]. In this period, the number of topics in high-density city research began to increase, and the degree of connection between the various parts began to strengthen. The research in this period laid the foundation for the current research stage.
3. Accelerated period (2015–present): Due to the accelerated globalisation process and expanded knowledge of high-density cities, the high-density city research field has reached an accelerated period. The main causes of this accelerated period are as follows: (1) The impact of high-density cities on the daily activities of people around the world is starting to become greater, which has had significant impacts on people's living environment [72]; (2) economic activities within cities are still valued [73]; and (3) modernisation has led to people's right to live and spiritual states being valued [74]. With the conceptual development of the field of urban studies, researchers have started to delve deeper into the fundamentals of high-density cities and to further study aspects of people and their living environments, such as general satisfaction, older adults' exposure to mental health issues, and thermal comfort, although there are still basic studies, such as those on impact city and land use. This research phase has shown specific and diversified research directions and has linked people and the urban environment while addressing urban resource shortages and environmental issues, including epidemics such as COVID-19, with the ultimate goal of building sustainable cities [75,76]. Although many specific research directions have already been proposed, most studies at this stage have attempted to propose even more directions because the research field has failed to form a complete system. The rapid development and concretisation of various research directions reflect the field's proximity to cities and their residents, as well as the raising awareness of the field and its significance. Therefore, this acceleration period will continue, and research directions will continue to be specified.

3.4.3. Keyword Clustering Analysis

A keyword cluster map was obtained from the keyword data using CiteSpace.v.6.1.R2. The basic principle of keyword clustering is the similarity between individual keywords and different group keywords, which can be used to form generalised groups. The cluster analysis of keywords was used to provide a clearer picture of high-density city research. Research directions could be grouped to enrich and complement each other through clustering. CiteSpace clustering calculations include LSI, LLR, and MI, with LLR being the most realistic result. Our keyword analysis using LLR yielded seven categories of keywords, as shown in Figure 11; specific information is shown in Table 10.

The first category was CFD simulation (#0). The keywords in this category included the analysis of void ground floors, urban street canyons, water channel experiments, pedestrian-level wind environments using CFD simulation, building porosity, pedestrian-level wind comfort, building height, and urban morphology in terms of computational fluid dynamics. The analysis of building porosity, pedestrian-level wind comfort, building height, and urban morphology was carried out with computational fluid dynamics. We found 75 articles in this keyword category, which had a silhouette value of 0.818; the main year of this category was 2016. In this category of keywords, the researchers mainly simulated the output and consumption of the target material using fluid dynamics to find the most relevant results for each city and the people living there.

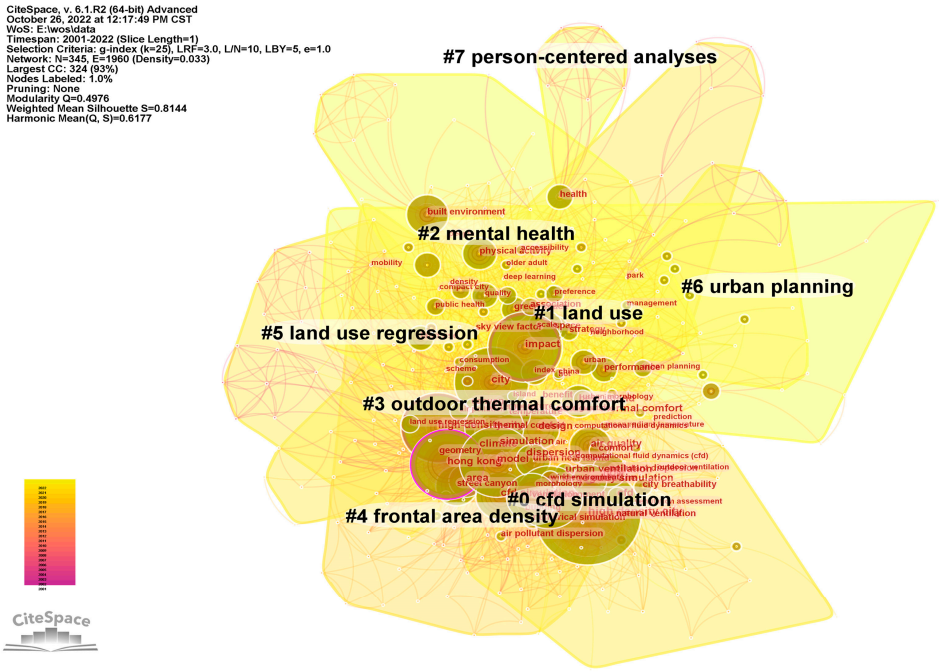

Figure 11. Co-citation network and clusters of papers on high-density cities from 2001 to 2022.

Table 10. List of cited clusters and number of contributed records.

Cluster-ID	Size	Silhouette Value	Year	Label (LLR)
#0	75	0.818	2016	CFD simulation; void ground floor; urban street canyon; water channel experiment; pedestrian-level wind environment | computational fluid dynamics; building porosity; pedestrian level wind comfort; building height; urban morphology
#1	55	0.685	2018	Supply chain resilience; fuzzy synthetic evaluation; supply chain vulnerabilities; industrialised construction; thermal index | urban green space; Google Street View image; pedestrian level greenery; local climate zone; urban morphology
#2	50	0.769	2017	High-density city; public health; nature sound; mood states; green landscape | physical activity; street view images; street greenery; high-density cities; dense urban environment
#3	48	0.825	2011	High-density city; urban performance; humid climate; mitigation strategies; anthropogenic heat | outdoor thermal comfort; high-density cities; local climate zone; subjective thermal perception; microclimatic conditions
#4	43	0.887	2014	High-density city; summer reference year; indoor thermal comfort; cooling energy consumption; building simulation | urban ventilation; block porosity; high density urbanisation; urban geometry; urban heat island

Table 10. *Cont.*

Cluster-ID	Size	Silhouette Value	Year	Label (LLR)
#5	32	0.881	2013	Land-use regression; high-density cities; vertical variation modelling; three-dimensional model; urban heat island | air pollution; urban surface geomorphometry; wind availability; mountainous high-density city; urban heat island
#6	12	0.958	2010	Urban planning; spatial pattern; morphological spatial pattern analysis; urban green spaces; visual characteristics | human perception; human activity density; visual characteristics; resident perceptions; high urban density
#7	9	0.998	2008	Heart rate; comparison; accelerometer; pedometer; validation | willingness-to-pay; Seoul; happiness; urban park; heart rate

The second category was land use (#1), which considered the enhancement of urban supply chain resilience using fuzzy synthetic evaluation, supply chain vulnerability analysis, and industrialised construction and thermal indexes. Further subcategories included urban green space, Google Street View images, pedestrian-level greenery, local climate zones, and urban morphology. We found 55 articles in this keyword category, which had a silhouette value of 0.685; the main year was 2018. The keywords in this category mainly focused on enhancing the resilience of urban supply chains through urban land use to ensure urban safety patterns. They were also focused on constructing urban green spaces.

The third category (#2) was mental health. It includes keywords related to urban systems, public health, nature sounds, emotional states, and green landscapes. There were also aspects of physical activity, including streetscape pictures, streetscape pictures, street greenery, and dense urban environments. We found 50 articles containing keywords in this category, which had a silhouette value of 0.769; the main year was 2017. The keywords in this category mainly focused on the physical and mental health of people living in a city and the guidance of mental health in public spaces.

The fourth category was outdoor thermal comfort (#3). This category included urban performance, humid climate, mitigation strategies, anthropogenic heat, the subjective thermal perception of people in urban outdoor spaces, and microclimatic conditions. We found 48 articles in this keyword category, which had a silhouette value of 0.825; the main year was 2011. The studies in this keyword category mainly focused on the thermal environment of cities and people's thermal comfort.

The fifth category was frontal area density (#4). This category included summer reference year, indoor thermal comfort, cooling energy consumption, building simulation in urban systems, neighbourhood porosity, high-density urbanisation, urban geometry, and urban heat islands related to urban ventilation. We found 43 articles in this keyword category, which had a silhouette value of 0.887; the main year was 2014. Studies of urban surface and facade densities have mainly focused on controlling urban air circulation to alleviate the heat island effect.

The sixth category was land-use regression (#5). This category mainly considered high-density cities belonging to urban systems, vertical change models, three-dimensional models, and urban heat islands, as well as urban surface landforms related to air pollution, wind availability, and high-density cities in mountainous areas. We found 32 articles in this keyword category, which had a silhouette value of 0.881; the main year was 2013. The studies in this keyword category mainly used land regression equations to study urban land cover.

The seventh category was urban planning (#6). Its subcategories included spatial patterns related to urban planning, morphological spatial pattern analysis, urban green spaces, visual characteristics, resident perceptions, and high urban density. We found 12

articles in this keyword category, which had a silhouette value of 0.958; the primary year was 2010. The main research focus in this keyword category was the utilisation of spatial patterns to better arrange urban spaces and serve urban dwellers.

The eighth category was person-centred analyses (#7). Its subcategories included heart rate, pedometers, urban willingness-to-pay, happiness, and urban park heart rate. We found 9 articles in this keyword category, which had a silhouette value of 0.998; the main year is 2008. The main research focus in this category was the happiness and psychological perceptions of urban individuals.

3.4.4. Research Clustering Timeline

In order to better understand the origin, historical development, and specific evolution of the high-density city research field, we used CiteSpace.v.6.1.R2 to create a keyword clustering timeline map. The results demonstrated that all keywords were first concentrated around 2005. From 2007 to the present, the field has experienced significant development, with the most rapid phase occurring around 2015. As seen in Figure 12, the temporal trend of keyword clustering in the field of high-density city research had the following characteristics:

(1) CFD simulation, land use, and mental health showed continuous development trends in recent years. Many subtopics appeared, indicating that this field has been the focus of academic research in recent years. A relatively large amount of research is being conducted under this category of keywords at this stage, which is characteristic of progress. Many other keywords also converged here, indicating increasing cooperation and communication between these fields and other fields, as well as their important role in realising the ultimate sustainable development goals of high-density cities.
(2) Outdoor thermal comfort keywords had an early origin and indicated the recognition of the heat island effect of outdoor spaces in cities. Researchers have gradually recognised ways of mitigating the heat island effect during high-density city development. However, development is somewhat hindered at this stage, and technical and theoretical enhancements are urgently needed.
(3) Frontal area density, land-use regression, and urban planning were found to have early origins. However, their development has been limited to different extents by the policies and technologies of each country, as well as a lack of innovation. However, because of the proven importance of these three keyword areas for the construction of high-density cities, they remain key areas of development at this stage.
(4) The category of person-centred analyses was developed and absorbed by other fields early on, indicating that the other research categories are mostly person-centred ideas.
(5) In general, the development of high-density urban research has mainly been concentrated in recent years, and the research topics have trended from general to specific, indicating the progress of academic understanding in the field of high-density urban research. These changes in development show that the field has been proven to be closely related to people's daily lives, which is why there are endless potential research directions [77]. As the construction of high-density cities continues, the high-density urban research field will continue to develop and gradually become a key area of research in the current academic era.

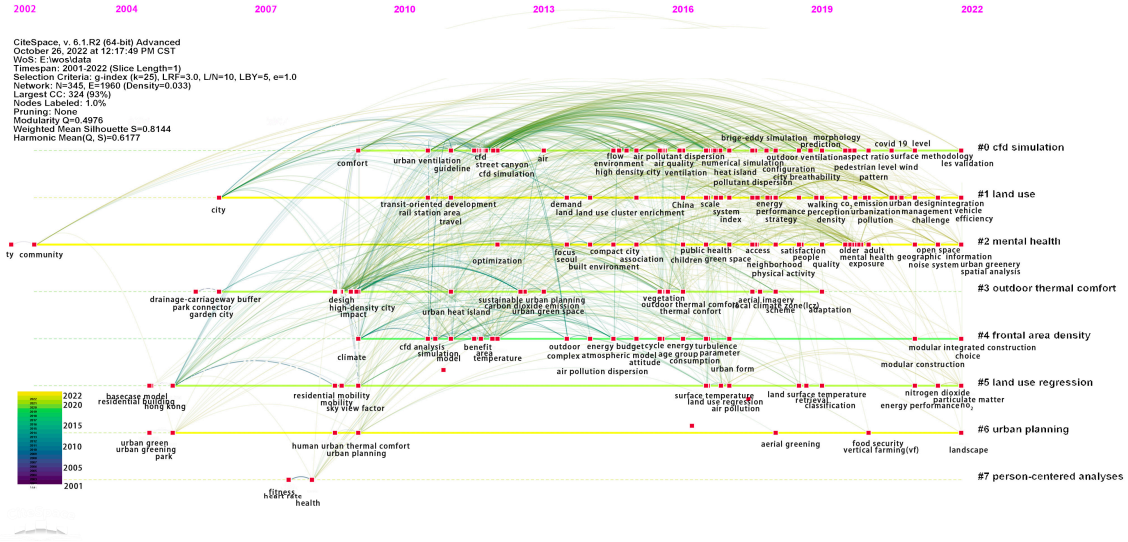

Figure 12. Timeline map of high-density city research from 2001 to 2022.

3.4.5. Research Trend Analysis

By studying the appearance point and duration of keyword use in the field of high-density urban research, we were able to better understand the degree of influence and development trends of each keyword. Using CiteSpace.v.6.1.R2, we investigated keywords in the field of high-density city research from 2001 to 2022 and found 25 emergent words. The calculation results are shown in Figure 13.

Keywords	Year	Strength	Begin	End	2001 - 2022
climate	2001	3.5	**2009**	2016	
geometry	2001	1.76	**2009**	2018	
guideline	2001	2.11	**2011**	2012	
wind environment	2001	3.09	**2012**	2018	
area	2001	3.67	**2015**	2018	
cfd simulation	2001	1.85	**2016**	2018	
hong kong	2001	5.02	**2017**	2018	
system	2001	1.86	**2017**	2018	
energy	2001	2.95	**2018**	2020	
city breathability	2001	2.95	**2018**	2020	
scheme	2001	1.91	**2018**	2019	
pollutant dispersion	2001	1.88	**2018**	2019	
performance	2001	1.79	**2018**	2019	
comfort	2001	1.79	**2018**	2019	
urban morphology	2001	2.08	**2019**	2020	
exposure	2001	4.22	**2020**	2022	
pollution	2001	3.16	**2020**	2022	
mental health	2001	3.16	**2020**	2022	
numerical simulation	2001	2.47	**2020**	2022	
pattern	2001	2.45	**2020**	2022	
built environment	2001	1.81	**2020**	2022	
public health	2001	1.77	**2020**	2022	
network	2001	1.75	**2020**	2022	
mortality	2001	1.75	**2020**	2022	
co2 emission	2001	1.75	**2020**	2022	

Figure 13. Top 25 keywords with the strongest citation bursts during 2001–2022.

The hot keywords in the field of high-density city research all appeared in the last 15 years or so, and they included the fields of climatology, geography, architecture, and environmental science. By about 2010, the number of reviews of hot topics in the field of high-density city research had begun to increase, research directions began to diversify and specify, and more attention was being paid to material flow and technological progress in urban systems. Since 2020, the causes of disasters in cities and people's mental health have been gradually emphasised, and CO_2 emissions, mental health, and mortality have become focus points of research [78].

4. Discussion

Based on our review, we can conclude that the research field of high-density cities is in a stage of rapid development. However, the research content is too fragmented, there is not enough communication between research topics, and grouping shows a relatively strong development trend. Regardless, the field of high-density city research will remain a focus for academics because they have recognised that research topics in this field are distinctly related to economic progress and modernisation, as well as to the daily lives of people living in cities. We also found that research topics are becoming more diverse and specific, and that research methods are increasingly incorporating computer technology, with more discussion of the correlations between the study subjects.

An important problem facing the field of high-density city research is that its rapid development has been caused more by external forces than by knowledge progression. This has led to a disruption in the evolution of topics and learning from previous research findings, the isolation of research directions, and a lack of clarity regarding the overall impact of high-density cities. Different research areas, such as CFD simulation and urban morphology, are still emerging, and different hazards, such as heat and floods, are often independently studied. The issue is that high-density cities are like organisms in the sense that they comprise systems of closely interconnected parts, so the various methods used to consider the various aspects of these cities must be used in tandem to achieve the best results. Fortunately, our review indicated that the field's is demonstrating better mutual cooperation and influence in the current acceleration period.

High-density cities play a crucial role in global urban development and significantly impact the daily lives of people around the world [79]. The COVID-19 outbreak accelerated the tightening of global urban space, limiting people's social spheres and filling city spaces with health facilities [80]. The negative impacts of high-density cities must be emphasised, and researchers must confront the question of how to weigh urban economic development and urban resident health. Moreover, the epidemic's impact must be considered in all phases of high-density urban construction. As people's awareness of sustainable urban construction grows, related research and new technologies will increase. The establishment of new research focuses will facilitate the output of research results and the strength of mutual exchange in this field. Furthermore, the direction of research is likely to shift towards the utilisation of the characteristics of high-density cities to achieve better urban development and thus improve the living environment of urban residents.

5. Conclusions

In this study, we searched the WoSCC for studies on high-density cities and used CiteSpace.v.6.1.R2 software to identify trends in the number of publications, the type and scope of journals, regional cooperation, distribution of author collaboration, and research institution collaborations. We also analysed the research areas considered in the journals and the most-cited articles to determine the current status and hotspots of high-density city research. Finally, we conducted co-present time zone and cluster analyses of the high-density city research keywords, and we predicted future research trends in this field.

Over the past 20 years, the development of high-density cities has significantly increased, and scholars have contributed to research on this subject in many ways, thus increasing the importance of high-density city research in urban development. Research

topics are also becoming more specific, influential, and relevant to the specific needs of each studied city.

The economic and population growth potential of high-density cities is unlimited. In this study, we constructed knowledge maps of high-density city research to provide a theoretical reference for scholars in this academic circle and to predict the development trends of this research field.

However, there are still limitations to this study. Since the concept of high-density cities is not recognised globally, the richness of the data sources is somewhat lacking. Only WosCC was used in this study, and others, such as CNKI, were not considered. The uncertainty of the data will result in inaccurate results. Thus, there is a degree of limitation in this study.

In the future, as research techniques improve and research within high-density cities advances, academics will become more proactive in their research on high-density cities. Academic researchers will also shift the focus of their research to how to better utilise the high-density feature, gain more economic benefits, awakening people in the city to socialise and communicate, etc. Additionally, be more proactive in building urban environments rather than being forced to solve urban problems. This process requires more academic researchers' time and time, as well as more communication and consensus.

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Abbreviation

Acronym/Abbreviation	Explanation
WoSCC	Web of Science Core Collection
TOD	Transit-oriented development
LSI	Latent Semantic Indexing
LLR	Log likelihood ratio test
MI	Mutual information
CFD	Computational fluid dynamics
CNKI	China National Knowledge Infrastructure

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