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Research hotspots and knowledge graph analysis of land use efficiency in China based on CiteSpace

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Abstract: *With the rapid growth of economy and the acceleration of urbanization, the problem of land use has become particularly prominent. To clarify the current research achievements and research directions in the field of land use efficiency, it is of particular significance to further enhance land use efficiency. In this study, 643 documents were obtained by searching the topic of "land use efficiency" on CNKI. The CiteSpace bibliometric tool was used to visually analyze the number of publications, authors and research hotspots. Since the 21st century, the number of documents in the field of land use efficiency has shown a fluctuating upward trend, going through three stages. There are many research hotspots on land use efficiency, which can be roughly divided into: Influential factors of land use efficiency, spatial-temporal pattern and regional differences of land use efficiency, industrial structure of land use efficiency, differences of land use efficiency in different land types, and land use efficiency under green development. The frontier of land use efficiency research in China mainly focuses on the "Yellow River Basin", "carbon emission", "intermediary effect" and "urban agglomeration".*

Keywords: *Land Use Efficiency, Citespace, Research Hotspot, Knowledge Graph Analysis*

1. Introduction

As an important natural resource, land is the spatial carrier for human survival and development[1]. Its efficient use is crucial for sustainable economic, social and environmental development.

The Outline of China's Land Planning (2016-2030) clearly states that China is facing four major challenges, including increasing resource constraints, increasing ecological environment pressure, urgent need to optimize the pattern of territorial space development, and improvement of the quality of land development. Therefore, improving the efficiency of land use has become a top priority. Land use efficiency is based on the embodiment of sustainable development and urbanization in resources, environment and social economy[2].

Land use efficiency means the maximum benefit generated at the lowest cost in the land use process. In recent years, domestic and foreign scholars have conducted extensive research on the land use efficiency, and Chinese scholars pay special attention to the urban land use efficiency and the influencing factors of green land utilization. By analyzing the factors such as financial decentralization, labor force, market segmentation, and scientific and technological innovation, the problems such as the low efficiency of urban land use, urban expansion and land waste are revealed. The spatial difference of land use efficiency is significant, so it is necessary to further build the economic cooperation mechanism between cities, promote regional coordinated development and complementary advantages, so as to promote the efficient use of urban land[3].

At the same time, foreign scholars pay more attention to the efficiency of agricultural land use. By analyzing the soil type, nutrient type and other elements, calculate the crop yield, and then evaluate the agricultural land use efficiency.

However, these research results are often scattered across different disciplines and literature and lack systematic integration. This study aims to use CiteSpace, a bibliometric analysis tool, to conduct a comprehensive and in-depth analysis of land use efficiency related research in China,To reveal research hotspots and construct knowledge map to provide reference and basis for promoting the research of land use efficiency. By analyzing the topics, titles, and keywords of a large body of literature,it can not only grasp the focus and trend of current research, but also make up for the shortcomings of existing research and provide guidance for future research direction. This has important theoretical and practical significance for promoting the rational use of land resources and improving land use efficiency.

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2. Data sources and research methods

2.1 Data source

Literature data used in this paper were taken from CNKI. To ensure the authority and accuracy of the analysis results, with the theme of "land-use efficiency", the literature source database was limited to academic journals, and the source categories were further limited to the chinese core journal criterion of PKU, CSCD, CSSCI, EI and SCI.A total of 1,245 documents were retrieved, and to ensure the timeliness of the analysis results, the time range was set from January 1, 2000 to November 2,2024. After screening one by one, the subject offset, literature duplication and academic literature were eliminated, and 643 documents were obtained as samples.

2.2 Study Methods

In this paper, the multiple and time-sharing scientific and technological literature visualization software—CiteSpace developed by Professor Chen Chaomei based on JAVA is used as a bibliometric tool. On the basis of land use efficiency, the generated key words such as "land use" and "influencing factors" are analyzed and summarized, and the network complex relationship generated by intersection, interaction, evolution or derivative is analyzed[4].

3. A bibliometric analysis

3.1 Analysis of literature release time

Through the effective analysis of the amount and time of publication, this paper can show the experts and scholars of the degree and direction of attention in the field of land use efficiency[5]. According to the search of the number of documents related to land use efficiency in CNKI (Figure 1), it can be seen that since the 21st century, the number of documents in this field has shown a fluctuating upward trend. 50 articles were published in 2024, reaching the peak number of documents in this field.

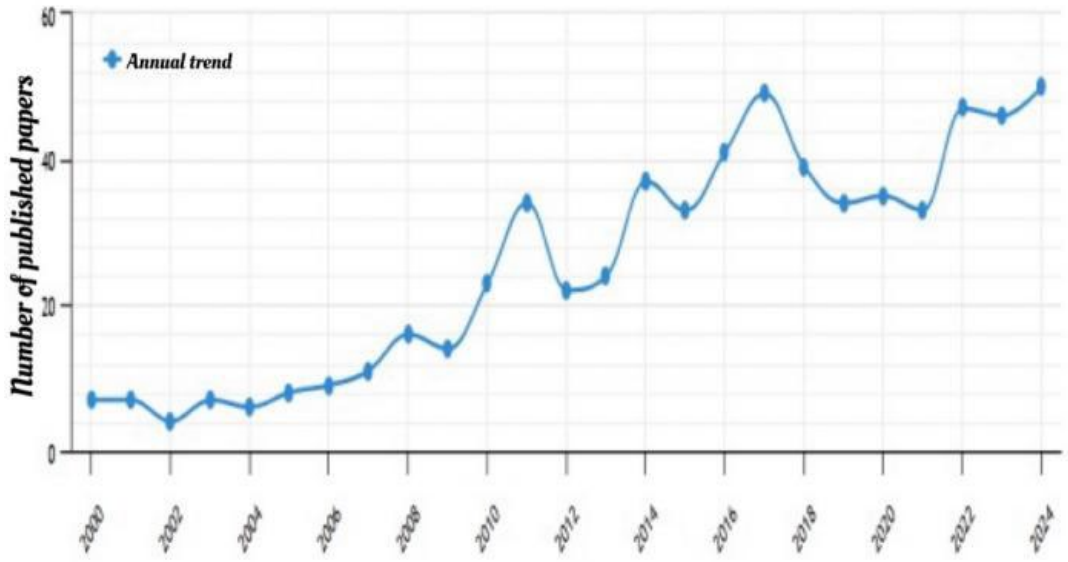

Figure 1: Trend of Chinese scholars' publication volume in the field of land use efficiency from 2000 to 2024

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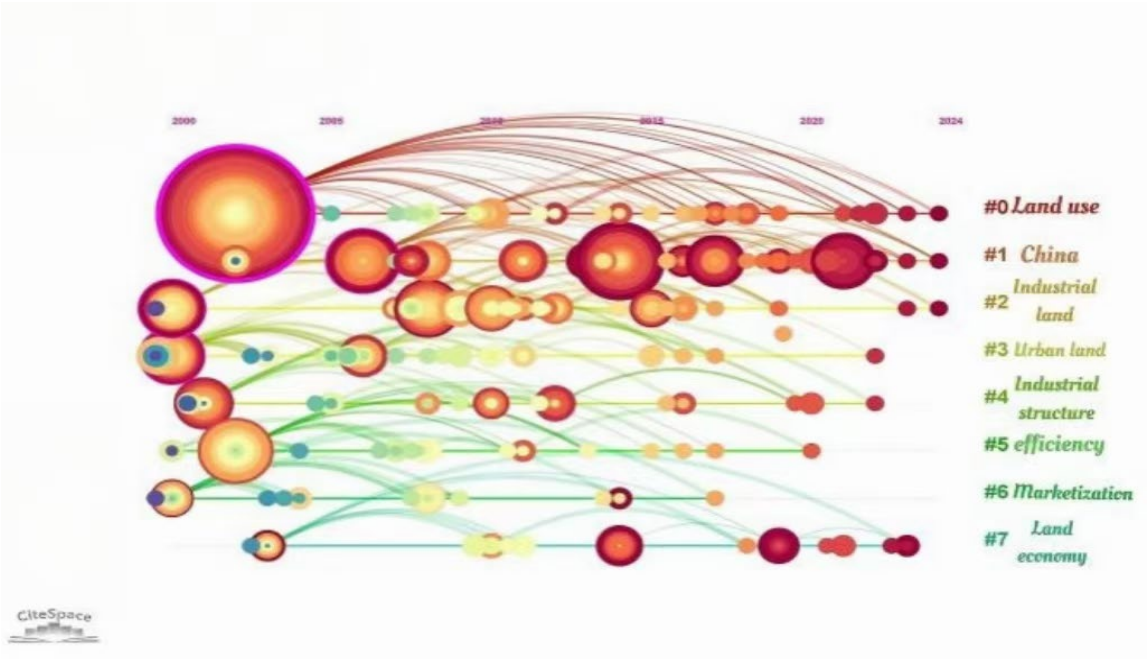

Figure 2: Keywords in the field of land use efficiency research from 2000 to 2024 across different years

As can be seen from Figure 2,the research heat of Chinese experts and scholars on the field of land use efficiency can be divided into three stages:

(1) Bud Exploration period (2000-2009): In 2000, Dong Liming and Yuan Liping proposed that with the rapid development of economic urbanization, especially after the phenomenon of "real estate fever" and "development zone fever" in the early 1990s, the problems and contradictions of land use in China have become increasingly prominent[6]. Experts and scholars have made preliminary exploration on how to improve land use efficiency from the perspectives of intensive use, optimized land allocation, spatial efficiency balance and land use potential.

(2) Problem Focus Period (2010-2015):In this stage, the number of publications has increased significantly compared with the previous stage, and the average annual number of publications is close to 29. Some experts and scholars put forward that the change of land use zoning in China at this stage presents new characteristics. The change characteristics of construction land, cultivated land, forest and grass land in northeast China, eastern China, central China and northwest China are analyzed[7]. It shows that the land use efficiency in this stage is characterized by high land use efficiency in eastern China and rapid growth in central and western regions. In addition, the urban land use efficiency in China is in an increasing state, but there are still some problems such as generally low land use efficiency, obvious spatial characteristics and regional differences[8-10].

(3) Rapid Development period (2016-present):This stage is the rapid development stage of land use efficiency research in China. In this stage, 374 documents were published on land use efficiency, accounting for about 60% of the total amount of land use efficiency published in China in the 21st century. With the expansion and development of regional integration and high-tech fields, the green land use efficiency and urban-rural integration in the land use efficiency have gradually become the focus of research by experts and scholars. At the same time, we made plans for deepening the reform of the system for promoting ecological progress, and proposed sound mechanisms for green and low-carbon development.

3.2 The core author

This paper uses the author module in CiteSpace to analyze the core authors in the field of land use efficiency, and further explore the focus issues in the field of land use efficiency in combination with the author's professional research direction.

According to the CiteSpace statistical analysis, there are 507 authors who have published the literature in this field. As can be seen from Table 1, Many authors have published literature in this field, and there is a significant gap in the number of literature release. Of the number of literature

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publications in this fieldthe author with the largest number of articles is Lu Xinhai, with a total of 23 articles. The main research direction is land consolidation and green transformation. In addition, there are 402 authors with one article, accounting for 79.29% of the total number of authors, indicating that the field of land use efficiency is the attention paid by more scholars, but many scholars are not deeply involved, and the research efforts in this field are further increased, and there is a broad prospect.

Table 1. The number of papers published by each author in the field of land use efficiency research from 2000 to 2024

Number of publications/piece	author	Number of publications/piece	author	Number of publications/piece	author
23	Lu XinHai	4	WuCi Fang	3	Liang LiuTao
16	Wu Qun	3	Yang Yong	3	Yuan KaiQi
16	Kuang Bing	3	Huang XianJin	3	Hu BiXia
10	Chen DanLing	3	Zhang ChaoZheng	3	Liu JingYu
8	Zhang AnLu	3	Cao Fei	3	Miao JianJun
7	Xue JianChun	3	Cui Wei	3	Liu MengBa
4	Qu FuTian	3	Jin XiaoBin	3	Li ShiPing

4. Co-occurrence analysis of literature keywords

4.1 Research hot spots

Advanced search on land use efficiency topics was conducted through CNKI, utilizing CiteSpace for keyword analysis of the literature. A keyword co-occurrence map was generated (Figure 3), which comprises 410 nodes and 589 connections, resulting in a network density of 0.007. Additionally, to group keywords based on similarity and maximize the identification of related terms, the keywords were clustered, yielding nine cluster labels related to the study of land use efficiency (Figure 4).

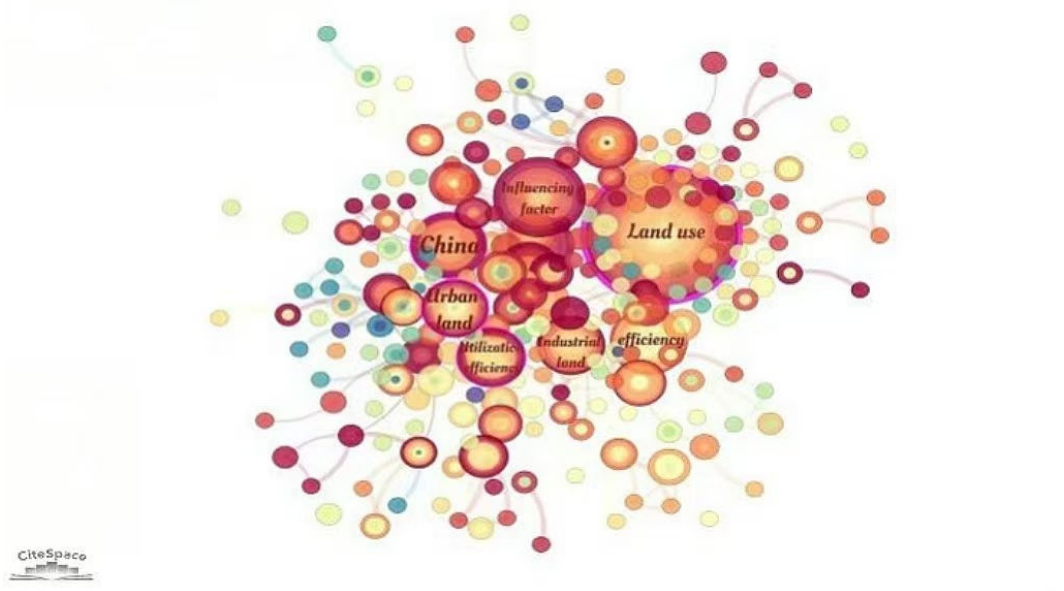

Figure 3. Co-occurrence map of key words in China's land use efficiency literature from 2000 to 2024

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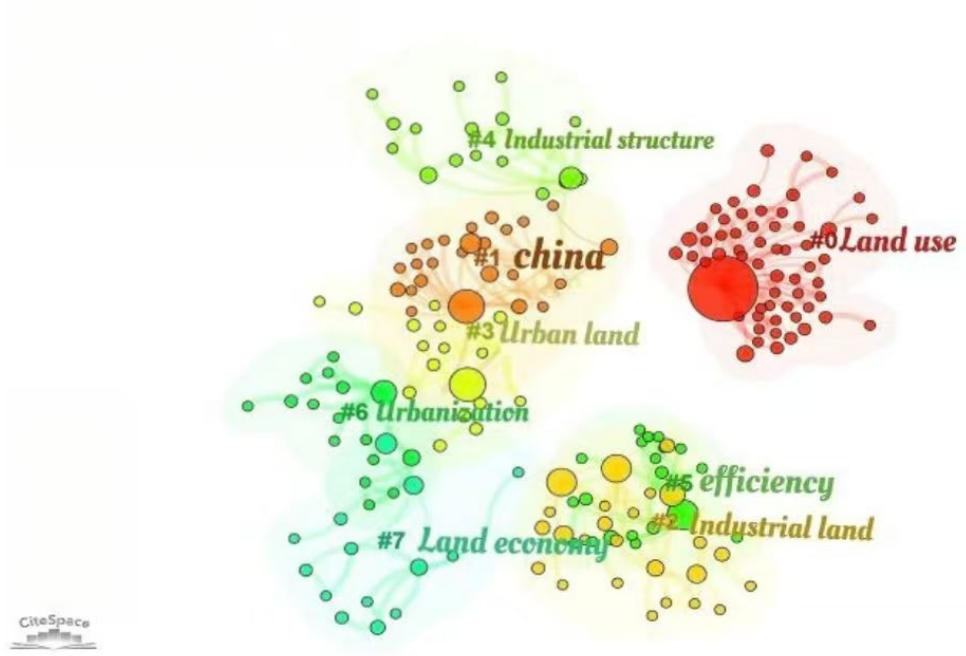

Figure 4. Keyword cluster analysis diagram of China's land use efficiency literature from 2000 to 2024

Considering the keywords and word frequency, as well as the clustering of topics and literature downloads in the field of land use efficiency, we can identify four prominent issues in this area in China: the influential factors affecting land use efficiency, the spatial-temporal patterns and regional differences in land use efficiency, the impact of industrial structure on land use efficiency, the variations in land use efficiency across different land types, and the relationship between land use efficiency and green development.

4.1.1 Factors affecting land use efficiency

There are various types of land use in China; however, issues such as low utilization rates, an unreasonable structure, and challenges related to environmental protection persist. Natural factors, including climate conditions, topography, and water resource availability, significantly influence land use efficiency.

Economic factors, including the level of economic development, adjustments in industrial structure, and the degree of marketization, significantly influence land use efficiency. Concurrently, social factors such as population growth, policies and regulations, and scientific and technological innovations also impact land use efficiency to some extent.

Climate warming extends the growing season for crops and expands planting areas; however, it also increases the frequency of extreme weather events, such as floods and droughts. These events significantly impact crop growth and, consequently, affect land use efficiency.

Complex terrains, such as mountains and plateaus, with significant fluctuations and high costs associated with land leveling, limit large-scale land development and utilization. Additionally, these areas often have poor soil quality and a scarcity of water resources, which further restricts the improvement of land use efficiency.

The higher the level of economic development, the more financial and technical support a region has to optimize land resources and enhance land use efficiency.

Industrial structure serves as the foundation for resource allocation, and varying industrial structures exhibit significant differences in the efficiency of land resource utilization. By optimizing the industrial structure, it is possible to reduce industries characterized by high resource consumption and low added value while promoting those with high technological content and substantial added value. This approach ultimately enhances land use efficiency.

In a competitive market, land resources are limited, and the competition among land users is becoming increasingly intense. To establish a strong presence in the market and secure more land resources, land users must focus on enhancing land use efficiency. This can be achieved by improving

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production technology and increasing investment in land development.

Population growth has placed immense pressure on the demand for land resources. As the population increases, the need for housing, transportation, education, and medical care continues to rise, resulting in a more constrained allocation of land resources. To meet these demands, agricultural land on the urban fringe is frequently converted into urban development, which adversely affects the efficiency and sustainability of land use.

Land policy is a primary tool for the government to exercise macro-control over land resources. Policies regarding land transfer, land taxation, and land planning significantly influence land use efficiency. The enhancement of land use efficiency through scientific and technological innovation is primarily evident in increased land productivity and the conservation of land resources. Such innovations can improve production efficiency, thereby reducing production costs and further enhancing land use efficiency.

4.1.2 Spatio-temporal pattern and regional differences of land use efficiency

The results indicate that overall land use efficiency has shown a steady improvement year after year; however, significant regional disparities exist. In economically developed regions, such as the eastern coastal areas, land use efficiency is markedly higher than in the central and western regions. This difference can be attributed to factors such as industrial structure optimization, technological innovation, and policy support.

Analyze the issue of land use efficiency from the perspective of temporal evolution. In the early stages of economic development, agriculture was the predominant industry, and land use was primarily focused on agricultural production. However, with the advancement of industrialization and the acceleration of urbanization, the modes of land resource utilization have become increasingly diversified, leading to a growing demand for industrial, commercial, and residential land. During this transition, both government and enterprises have begun to emphasize the intensive use and efficient allocation of land resources. By optimizing the land use structure and enhancing the intensity of land use, the efficiency of land utilization can be continuously improved.

After entering the mature phase of economic development, the growth rate of land use efficiency has gradually slowed. On one hand, the increasing scarcity of land resources has limited the availability of new land. On the other hand, due to technological advancements and industrial upgrades, the land use efficiency of certain traditional industries has reached a high level, making further improvements more challenging. Therefore, during this mature phase of economic development, enhancing land use efficiency requires a greater focus on connotative development. This involves tapping into the potential of existing land resources through technological innovation, systemic reform, and management improvements, ultimately achieving the sustainable utilization of land resources.

Analyze the efficiency of land use from the perspective of spatial distribution. In the eastern coastal areas, characterized by their advantageous geographical location, developed economic foundations, and well-established industrial structures, land use efficiency is generally maintained at a high level. These regions experience rapid urbanization, high population density, and a relative scarcity of land resources, prompting a greater emphasis on intensive land use and efficient allocation. Furthermore, the eastern coastal areas exhibit strong scientific and technological innovation capabilities and openness, which significantly support improvements in land use efficiency. In contrast, land use efficiency in the central and western regions is relatively low. The economic foundations in these areas are weaker, with a more limited industrial structure that primarily relies on traditional agriculture or resource-based industries. Insufficient investment in science and technology, coupled with limited innovation capacity and underdeveloped markets, has hindered the full and effective utilization of land resources in the central and western regions. Additionally, natural factors such as landforms and climatic conditions also impact land use efficiency in these areas to some extent. Reason: Improved clarity, vocabulary, and technical accuracy while maintaining the original meaning.

4.1.3 Industrial structure of land use efficiency and the differences of land use efficiency in different land types

In the process of upgrading industrial structures, the emergence of high-efficiency sectors, such as high-tech industries and modern service industries, has led to more intensive and efficient utilization of land resources. These sectors, characterized by high added value and low resource consumption, effectively reduce dependence on land resources while enhancing economic output per unit of land area. For instance, in the development of high-tech industrial parks, strategic planning and layout can

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facilitate the efficient use of land resources and stimulate rapid regional economic growth. The relationship between land use efficiency and industrial structure is also evident in the coordinated development among regions. Due to variations in natural resource endowments and levels of economic development across different areas, land use efficiency and industrial structures exhibit distinct characteristics. Therefore, in promoting improvements in land use efficiency and optimizing industrial structures, it is essential to consider the differences and complementarities among regions. This approach will enable the optimal allocation of land resources and industrial structures through regional cooperation and coordination.

4.1.4 Land use efficiency under green development

With the acceleration of global industrialization and urbanization, the pressure on resources and the environment has become increasingly pronounced. The traditional development model characterized by high energy consumption and high emissions has resulted in a shortage of land resources. Furthermore, the excessive exploitation and improper utilization of these resources have led to significant ecological degradation. Green development has established clear requirements for land use, which include, but are not limited to, optimizing the allocation of land resources. Through more scientific and rational planning, limited land resources can yield maximum economic and social benefits. Efforts will be made to promote the economical and intensive use of land, reduce unnecessary waste, and enhance land use efficiency. Additionally, it is essential to strengthen the ecological protection and restoration of land, taking proactive measures to rehabilitate and manage damaged land resources to ensure the continued functioning of their ecological roles.

4.2 Research frontiers

By utilizing CiteSpace's Burstness sudden word detection tool, the sudden word spectrum of land use efficiency is analyzed to better identify the research frontier and dynamic changes in the field of land use efficiency (see Figure 5).

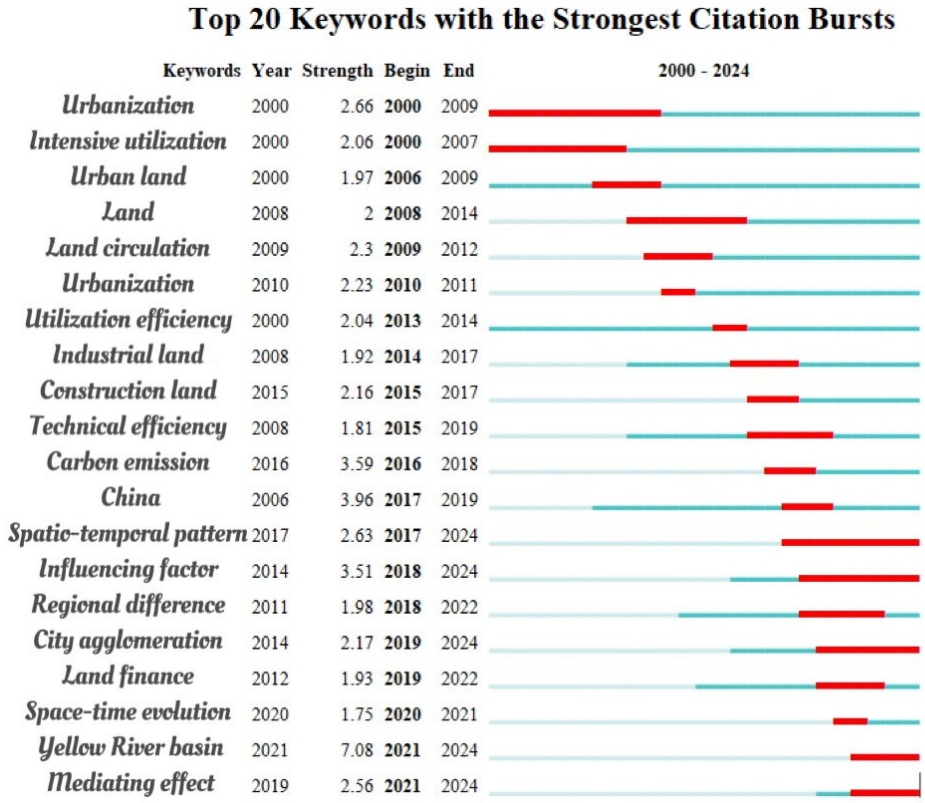

Figure 5. Emergent word spectrum of land use efficiency research

From the perspective of the temporal framework of the sudden word spectrum, the research on land use efficiency in China can be categorized into three distinct stages. Each stage aligns with China's national conditions and developmental status, demonstrating relevance and timeliness.

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Phase 1 (2000-2007): This stage is characterized by a limited number of sudden keywords, prolonged intervals, and low intensity of emergence. It represents the initial phase of research on land use efficiency in China. During this period, only three significant keywords emerged: "intensive use, and "urban land. Most of these keywords appeared in 2000, but they exhibited a long duration of relevance. Notably, the emergence intensity of "urbanization" was 2.66, and its influence persisted until 2009, spanning nine years. Consequently, urbanization is a crucial process in China's social and economic development. Overall, the study of land use efficiency during this phase was significantly influenced by the rapid growth of the urban economy. As a result, issues such as intensive land use, the efficient allocation of urban land, and strategies to enhance urban land use efficiency became prominent topics of discussion during this period.

Phase 2 (2008-2012): This stage marks the gradual development of research on land use efficiency. During this period, the concepts introduced in the previous stage continue to evolve, with three new terms— "land circulation, and simultaneously. Consequently, land is transferred and managed in various forms, prompting Chinese scholars to increasingly focus on enhancing land use efficiency throughout the process of land circulation. Notably, for the first time, Chinese scholars have identified that land fragmentation also impacts land use efficiency. Additionally, building on the research frontiers established in the previous stage, urban land use efficiency remains a prominent topic of investigation.

Phase 3 (2013-2024): This stage represents a period of rapid development in the research frontier of land use efficiency. In addition to building on the previous stage, a significant number of new terms have emerged, indicating a surge in China's research in the field of land use efficiency. From the perspective of emergence intensity, the term "Yellow River Basin" stands out with a remarkable intensity score of 7.08, and its emergence has been ongoing since 2021.Combined with emerging terms such as "carbon emissions and "technical efficiency, it is evident that, under the demands of green development and the rapid advancement of high and new technologies, the Yellow River Basin has become a focal point for research. Investigating the spatial and temporal patterns, as well as the influencing factors of various land uses, has emerged as a significant area of interest in the field of land use efficiency. This focus is closely linked to the unique geographical location and ecological environment of the Yellow River Basin, where changes in land use are crucial for the sustainable development of both the region and the nation as a whole.

5. Conclusion

(1) From the perspective of the publication time, since the 21st century, the number of publications in this field has shown a fluctuating upward trend. Chinese experts and scholars on the field of land use efficiency in the study of heat can be divided into three stages: bud exploration period (2000-2009), focus period (2010-2015), rapid development (2016-present) three stages. Influenced by the national conditions of each period, the needs of national economic development and national policies, the research focus of each period has its own emphasis, but all have timeliness.

(2) From the perspective of the authors of the publication, there are many scholars in the field of land use efficiency in China, and the field has gradually paid more attention to this field, and the research efforts have been further intensified, with broad prospects. However, many scholars are not deep and are not closely connected with each other.

(3) From the perspective of the research frontier, the research on land use efficiency has obvious stages: the initial stage, the gradual development stage and the high-speed development stage. All the stages are in line with China's national conditions and development status quo, showing timeliness. At present, China mainly focuses on the "Yellow River Basin","carbon emission", "intermediary effect" and "urban agglomeration", etc. In the future, with the further development of economy and society and the introduction of new policies, keywords and research hotspots in this field will continue to emerge from a more refined and detailed perspective. In general, Chinese scholars have studied the field of land use efficiency for a long time, involved many types, and has the characteristics of timeliness and practical application.

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