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The science of rural human settlements: a comprehensive overview

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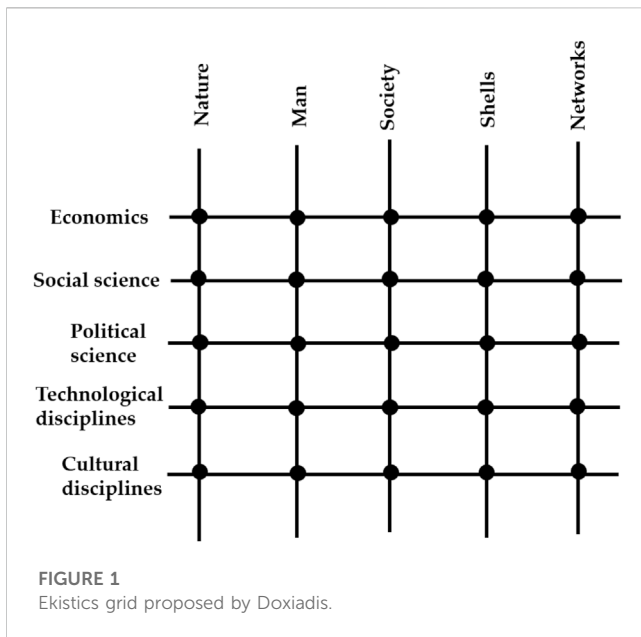
In the process of rapid urbanization in the world, many villages are facing a series of problems such as depopulation, population ageing, insufficient infrastructure, and public service facilities. In order for better rural development and full implementation of the 2030 sustainable development goals, we should hammer at improving the rural human settlements. Based on the science of human settlements proposed by Constantinos Doxiadis, bibliometric analysis was made on studies related to rural human settlements in the last 25 years. Through analysis, we believe that the number of related studies will gradually increase. Currently, the improvement of the rural ecological environment and the creation of a healthy rural human settlement environment are two hot topics. It is very likely that these topics will also be highly focused in the following decades. With the gradual development of rural areas and the improvement of the material lives of people, more and more scholars will pay attention to higher-level demands such as rural cultural environment and self-realization of villagers. By reviewing literature related to rural human settlements, we can comprehensively consider different aspects in rural human settlements. This is quite beneficial for the comprehensive development of rural human settlements. Scholars in different countries have similar focuses related to rural human settlements. However, because of different country conditions, the focuses of researchers have some obvious differences. Relevant literature contributes to the development of the science of human settlements.

KEYWORDS

the science of human settlements, rural human settlements, rural living environment, Citespace, housing, infrastructure, rural residents

1 Introduction

As early as the 1950s, Greek architect and urban planner Constantinos Doxiadis proposed ekistics as a science of human settlements (Doxiadis, 1968). Since then, the science of human settlements has been gradually moved from an interdisciplinary to a condisciplinary science. Doxiadis (1968) proposed the ekistics grid to systematically explore the human settlements (Figure 1). The grid link five elements (nature, man, society, shells, networks) with sciences (economics, cultural disciplines, social sciences, political sciences, technological disciplines) (Acar, 2022). We can improve the relationship between humans and society, nature, buildings and structures, as well as their qualities. In this way, the living environment can be more harmonious. At the same time, from the perspective of the science of human settlements, people are encouraged to optimize their protective space so that they can have a suitable distance from other people, animals and objects that they can contact



with them without any kind of discomfort. The science of human settlements also guides people to comprehensively consider time, space, actual situations, and personal ability and change their environment to achieve a balance between humans and the environment (Doxiadis, 1970a; Doxiadis, 1972).

As a modernist architect and urban planner, Doxiadis persists in a condisciplinary understanding of human settlement. He also wants to position the design discipline as a primary contributor to the decolonization and modernization of nation-states (d’Auria, 2015). Doxiadis advocates scientific planning for urban and rural areas. A comprehensive understanding of human settlements can lay a solid foundation for scientific planning (Hull, 2008; Madanipour, 2010). It can be seen from Figure 1 that there are twenty-five node points formed by 5 elements and 5 kinds of science. Furthermore, there are 33,554,431 combinations of the 25 nodal points. Diagrammatic reasoning supports Doxiadis to legitimize the scientific foundations of planning decisions for development. This provides a new insight into urban and rural planning. Doxiadis highlights the importance of shifting from a descriptive to a prescriptive mode of intervention to participate in the actual development of human settlements. Because he thinks human settlements continuously experiences dynamic change and are different in different periods, he also highlights the importance of plan for dynamic

growth (d’Auria, 2015; Doxiadis, 1970b). When Doxiadis proposed the science of human settlements, villages, towns and cities were all highly highlighted. Besides, Doxiadis pointed out that it was not possible to ignore its size when we explored the quality of life and other phenomena in the human settlement environment. He once divided human settlements into urban human settlements and rural human settlements. Thus rural human settlements is an essential part of the science of human settlements and it should be distinguished from the urban human settlements (Doxiadis, 1970b).

The science of human settlements proposed by Doxiadis considerably influenced academic circles. Many scholars further explored the science of human settlements. Doxiadis established the research center Athens Center of Ekistics in 1963 and started a journal in 1950s. The journal was named Ekistics: The Problems and Science of Human Settlements in 1970s (JSTOR, 2023). These attracted Greek, and even world scholars, to focus more on the science of human settlements. As early as 1975; Fookes (1975) thought the science of human settlements could provide a framework for study and suggested that it could become a pivot of the school curriculum. Liangyong Wu, an academician of the Chinese Academy of Sciences, has comprehensively explored the science of human settlements, especially in the Chinese context. Professor Wu also played an essential role in increasing the influence of the science of human settlements in Chinese academic circles (Mao, 2019). In 1976, after the death of Doxiadis, Scholar Jean Gottmann praised Doxiadis’s hard work on improving the environment, the human condition, and the world. His influence on academic circles has persisted until now. In recent years, his creation still has considerably influenced many scholars. For example, Gao and Hu (2022) used Tibet, China as a case to examine the factors affecting rural human settlements based on the science of human settlements proposed by Doxiadis; Farizkha et al. (2019) used multi-variables to explore factors which can have a great influence on urban settlement growth. The choice of variables highly relies on the Ekistics grid proposed by Doxiadis. Besides, some researchers tried to review some specific aspects of human settlements. To have a better understanding of research on carbon-oriented climate change response and improve human settlements, An et al. (2022) comprehensively reviewed related research. Xuan et al. (2023) reviewed past research on the impact of the human settlement pedestrian environment on the gait of elderly. Liu and Zheng (2021) reviewed research on the exploration of strategies for improving human settlement environment from the perspective of land engineering. To explore human evolution in a better manner, Matisoo-Smith (2015) comprehensively reviewed the research on

TABLE 1 The top five highly cited papers.

Paper	Year	Citations	Journal
Impact of diet in shaping gut microbiota revealed by a comparative study in children from Europe and rural Africa	2010	3,494	Proceedings of the National Academy of Sciences of the United States of America
Environmental exposure to endotoxin and its relation to asthma in school-age children	2010	1,348	New England Journal of Medicine
Green space, urbanity, and health: how strong is the relation?	2006	1,091	Journal of Epidemiology and Community Health
A global analysis of human settlement in coastal zones	2003	980	Journal of Coastal Research
Anthropogenic transformation of the biomes, 1700 to 2000	2010	805	Global Ecology and Biogeography

ancient DNA and human settlements in the Pacific region. Pierantoni et al. (2020) explored how COVID-19 pandemic changed people's reorganization of human settlements through a comprehensive review. However, few researchers have conducted a comprehensive review of all the literature on the science of rural human settlements. We tried to comprehensively review research related to all different aspects of the rural human settlements all over the world in the last 25 years based on the science of human settlements proposed by Doxiadis and make up the research gap through this research.

Many countries around the world are undergoing rapid urbanization (United Nations, 2018). Different from cities and towns, rural areas have small populations, small-scales of economic activities, large proportion of agricultural population, low education level, scattered population distribution, and low housing density. Rural economic development highly relies on the primary industries such as plantation, forestry, animal husbandry, and fishery (Li et al., 2018; Ramasamy and Ramachandran, 2019; International fund for agriculture development, 2021). Rural areas in many countries are facing a series of problems, such as income inequality between urban and rural areas, rural hollowing, inadequate rural infrastructure, and backward public services (Naiz, 2016; Clark, 2020; Hutchings et al., 2022). The importance of rural areas in all countries is implicit. The improvement of human settlements in rural areas is undoubtedly conducive to sustainable development. According to actual demands, more and more scholars have started to focus on the improvement of rural human settlements. Our study is conducted based on the following assumptions.

1. The specific circumstances of rural human settlements in different villages are different. The aspects of rural human settlements which are needed to be improved are also different in different villages.
2. The rural human settlements are constantly changing. The rural human settlement issues to be solved for the same village are different in different periods.

To improve the rural human settlements, scholars with different discipline backgrounds studied the rural human settlements based on their own conditions and advantages. When researchers did research on rural human settlements, they constantly changed the focus of research according to their demands. They value the importance of rural human settlement improvement. Like the countryside is a crucial part of a nation, the rural human settlements is a critical part of the science of human settlements. For scientific development, scholars have to summarize the past and look forward to the future. In this study, based on the science of human settlements proposed by Doxiadis, the research related to rural human settlements in the past 25 years were reviewed. The purpose is to have a better understanding of the related research and reasonably guide subsequent research. In this study, we tried to answer the following questions to promote the development of the science of human settlements.

Q1: How did the amount of published papers change?

Q2: From the perspectives of the disciplines, countries, authors, and journals of the papers published, what were the overall situations in the past 25 years? How were these changed?

Q3: Which research topics are hotspots? Which research topics are seldom studied but have big research potentials?

Q4: From the perspective of citations of related literature, how did the research literature about rural human settlements impact on the academic circles? Which papers were frequently cited? Why these papers were frequently cited?

The advantage of Bibliometric analysis is that a large amount of research papers can be analyzed. The common software which can be used to do the bibliometric analysis includes VOSviewer, Gephi, Citespace, and so on. By using Bibliometric software, researchers can make visualized analysis on a large number of research in the past. Such softwares can be used to comprehensively analyze the article titles, keywords, authors, topics, and other information in databases according to users' requirements. The analysis of the information can help with a comprehensive overview of existing research and also help to explore research trends and potential knowledge gaps. This can guide future research. The science of human settlements is a science in which the relationship between humans and environment is explored. In the science of human settlements, human settlements are systematically and comprehensively studied from social, economic, cultural, political and technological aspects (Doxiadis, 1970a; Doxiadis, 1972). From the perspective of the science of human settlement environment, the range of research related to rural human settlement environment is very wide and there is a lot of research in the past. The Bibliometric method has obvious advantages in the analysis of such research.

We made Bibliometric analysis on research on the rural human settlements around the world with the core collection database of Web of Science and bibliometric analysis software Citespace. We not only analyzed the data but also carefully read many research papers to have a better mastery of existing research. On the basis of a comprehensive analysis, we proposed prospects for future rural human settlements research.

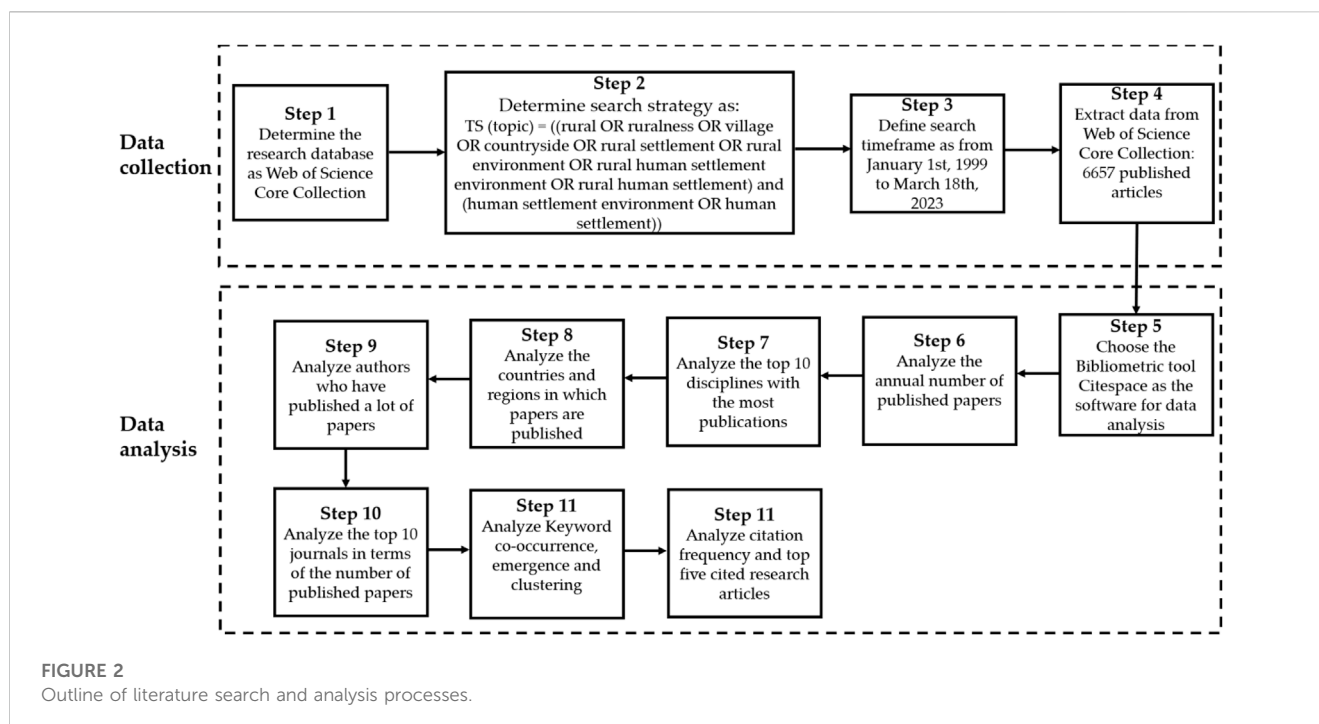
2 Research methods and data

2.1 Outline of literature search and analysis processes

The researchers did the literature search and analysis processes shown in Figure 2 to review the research on rural human settlements in the past 25 years, explore different aspects of rural human settlements, and answer the above research questions.

2.2 Data collection

Web of Science Core Collection was used as the database. More specifically, this includes Science Citation Index Expanded, Social Science Citation Index, Arts and Humanities Citation Index, Emerging Sources Citation Index, Current Chemical Retractions and Index Chemicus. The advanced search function of Web of Science is used. To include as many relevant papers as possible within the scope of our review and effectively exclude irrelevant literature, we searched according to the topic and developed a search strategy containing a lot of related words. The search strategy is 'TS = ((rural OR ruralness OR village OR countryside OR rural



settlement OR rural environment OR rural human settlement environment OR rural human settlement) and (human settlement environment OR human settlement))’.

The time span is from 1 January 1999 to 18 March 2023. In this way, we can search all related literature in the past 25 years. We referred to the related information on search operator and the function of parentheses for operator precedence provided on the official website of Web of Science and searched with the search strategy (Web of Science, 2021). We did not use the exact search function in advanced search. The exact search function can limit the search to the exact term people type. Without using the exact search function, Web of Science can search some relevant words according to words we enter (Web of Science, 2021).

The search was conducted on 18 March 2023. 6,657 published articles were obtained. We downloaded the full records of the 6,657 article. In the records, the authors, publication times, publication institutions, countries, keywords, and other information of each paper are recorded in the form of text. We used all 6,657 published articles in the following analysis.

2.3 Data analysis

The bibliometric software Citespace was used for the analysis. Citespace was developed by Professor Chaomei Chen of Drexel University in the United States based on Java language. Citespace is a visualization tool for literature that can be used to comprehensively analyze authorship patterns, institutions, cities, countries, keywords, topics of general interests, and other information in a literature analysis. It allows researchers not only to comprehensively analyze past research but also to identify future trends in different fields (Naiz, 2016; Niu et al., 2022).

We imported the text file containing information of the 6,657 articles downloaded into the Citespace and information of related literature was comprehensively analyzed. We analyzed the number of publications and the year-by-year change trend of the number of annual publications. We summarized the number of publication by a line chart, which could help us to have a better understanding of the changes in the number of publications and support subsequent analysis and discussion.

Subject category analysis could help us to have a better understanding of disciplinary backgrounds in which a lot of research on rural human settlements are conducted and trends of past research. When we founded out the related information of these 6,657 papers from Web of Science, we can generate disciplinary analysis map. We chose the top 10 subject categories in terms of the number of papers published. We presented related information in the form of a chart.

An analysis on the countries where papers were affiliated can help us to have a better understanding of related research from the perspective of locations and have a more comprehensive understanding of the research on rural human settlements in different countries around the world. Because different countries have different national conditions, the main focus of different countries can be different. We tried to explore the number of published papers in different countries in different time stages through a comprehensive analysis. When we read txt file with Citespace, Citespace could identify the country where each paper affiliated and summarize the related conditions. We showed the number of papers published by researchers in different countries in the form of the co-occurrence map. Bigger circles represent large amounts of papers published in the countries. We focused on analyzing countries with a big number of papers published and we only displayed these countries or regions.

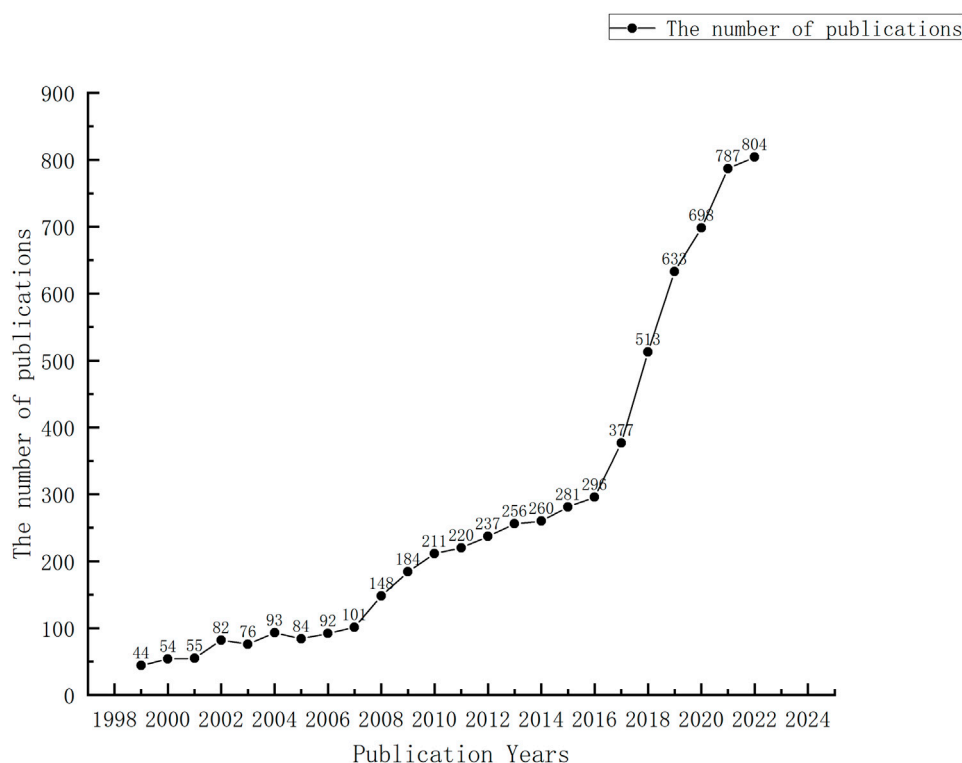


FIGURE 3

Annual distribution of the number of articles published.

An analysis on related authors can help us to have a better understanding of authors who have studied rural human settlements and specific aspects of rural human settlements focused by them. This can help us to summarize the related research on rural human settlements and guide future research. Citespace can read the information of related authors and publishing time in the txt text input. We generated a time zone map for authorship analysis in Citespace. This picture can reveal the authors who have published a lot of papers and the time of the publication of their first papers. The bigger circle represents the bigger number of papers published by the author. This picture only shows authors with 2 or more related papers published.

We read txt text through Citespace and analyzed the keywords of these 6,657 papers. First, we generated a keyword co-occurrence map within Citespace. It displays words with a high occurrence frequency based on the size of the circles. Besides, through keyword burst analysis, we explored related keywords whose frequency of occurrence sharply increased in different periods, which could help us to have a better understanding of research hotspots that appeared in different periods. Finally, We classified related keywords with Citespace and generated multiple categories. Different categories of keywords can show multiple main directions of related research.

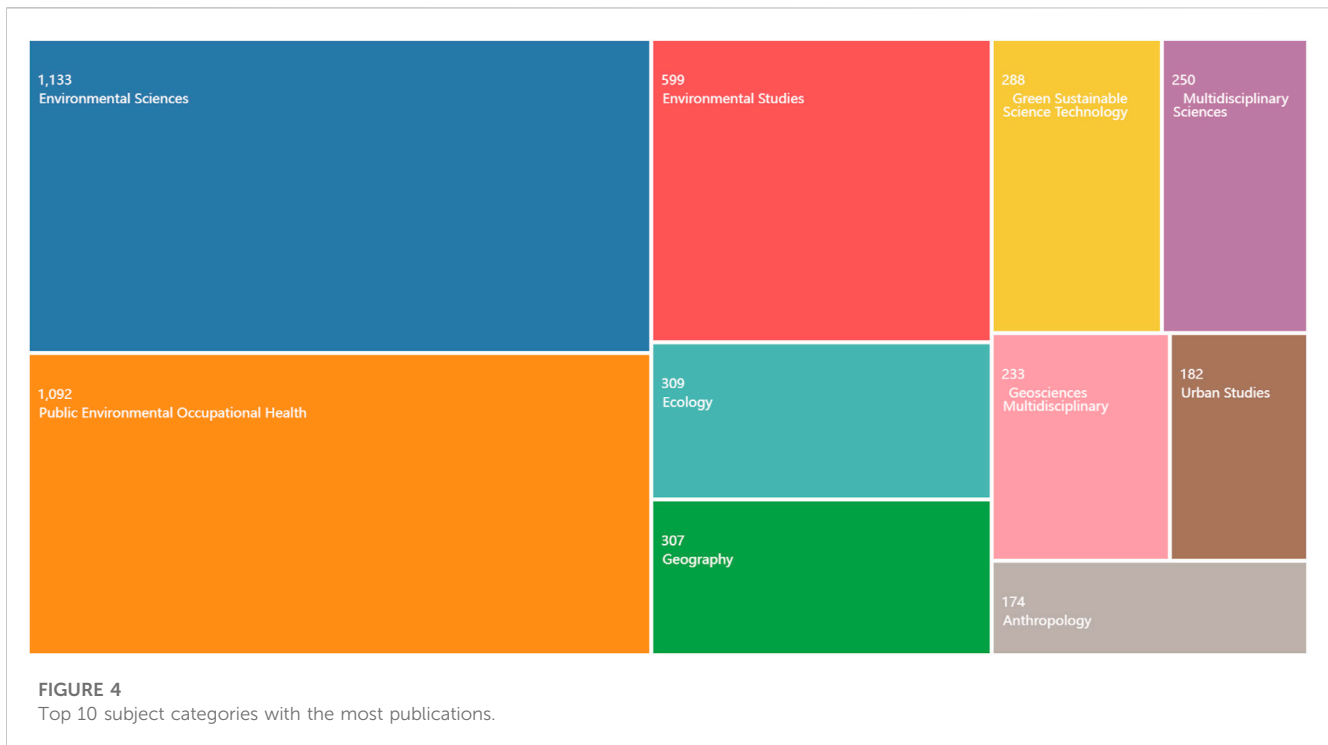
When we downloaded related papers on the Web of Science, we could obtain the number of citations of the 6,657 papers and the titles of the highly cited papers among them. We displayed the number of citations of related literature each year in the form of the line chart, which could show the year-to-year changes. We selected

the top 5 highly cited papers for analysis and tried to explore why these papers were highly cited.

3 Results and discussions

3.1 Number of publications

Figure 3 shows the number of published papers from 1 January 1999 to 18 March 2023. In 1999, there were only 44 papers published. In 2022, the number of papers was 779, which was 17.7 times of the number of published papers in 1999. To be specific, from 1999 to 2006 (the first stage), the number of published papers increased slowly and the total number of published papers in each year did not exceed 100. From 2007 to 2016 (the second stage), the number of published papers increased steadily. The average increase rate in the second stage was larger than that in the first stage. The number of published papers in 2016 was nearly three times of that in 2007. From 2016 to 2022 (the third stage), the number of published papers increased rapidly. The number of published papers in 2022 was 483 larger than that in 2016. We only collected the data before 18 March 2023 and relevant literature published in the whole year of 2023 is not included. The number of related articles published from 1 January 2023 to 18 March 2023 is 71. We did not list the number of publications in 2023 in Figure 3 to avoid any ambiguity. In general, the rural human settlement environment is a research direction that more and more attention is paid to. In the last decade, the number of



published papers was big and the annual number of published papers increased significantly. The increase reflects that there is an increasing number of scholars conducted research on rural human settlements and devoting to the improvement of rural human settlements. There is an overall gradual increase in the number of scientific articles published in Web of Science each year worldwide (Larsen and von Ins, 2010). This also contribute to the increase of rural human settlements related research in Web of Science.

3.2 The subject categories of the papers

By analyzing the papers based on their subject categories, we can have a more comprehensive understanding of the related research. The subject categories of the papers in Figure 4 below is based on the categories in Web of Science. In this figure, ten categories with the biggest number of related papers are listed. The number correspond to each subject category indicates the number of related literature of this subject category. The top three subject categories in terms of the number of published papers are environmental sciences (1,133), public environmental occupational health (1,092), and environmental studies (599). The related research under these three subject category backgrounds focuses on the rural environment. Besides, Public Environmental Occupational Health also highly focuses on the health condition of rural residents.

In the journals of the environmental science subject category, scholars published a large number of papers related to rural human settlements in sustainability. The five categories of sciences in the Ekistics Grid extensively include the aspects of economics, cultural disciplines, social sciences, political sciences, and technological disciplines. By promoting the social, economic, environmental, cultural and technological sustainable development in the rural

areas, we can solve the issues in five main aspects of rural human settlements and achieve better development of rural human settlements. Among journals in public environmental occupational health, a large number of papers related to rural human settlements have been published in the International Journal of Environmental Research and Public Health and BMC Public Health. At the same time, the International Journal of Environmental Research and Public Health belongs to the category of environmental science. The International Journal of Environmental Research and Public Health focuses on environment and health issues. There are topics such as economic health, public health, environmental health, and occupational health. In BMC Public Health, public health issues are explored from social, environmental, occupational, behavioral, and other aspects and public health is promoted from different aspects (BMC public health, 2023). In the Ekistics Grid proposed by Doxiadis, man is one among five elements. The science of human settlements highlights the importance of man in the environment. In addition, health issue is an important social issue. This can help to explain why there are many research concern about improving the environment and residents' health conditions simultaneously.

Land is one of the journals with the a large number of papers published in category of journals of environmental studies. Land extensively covers many different environmental topics, such as resources research and management (land, food, water and energy), landscape and biodiversity protection, and climate change and tackling strategy (Land, 2023). To improve the rural human settlement environment, we also need to explore these topics.

The related research under the disciplinary background of ecology (309) whose number of published papers ranks fourth. Landscape Ecology is a representative journal with a big number of related papers published in this category. This journal concentrates on the ecological understanding of spatial

heterogeneity. The main research issues considered in this journal extensively include ecology, management, conservation, planning and sustainability of landscapes and human settlement system (Springer, 2023). Related research includes the impact of human settlement growth on vegetation productivity (Zhao et al., 2012), human-carnivore coexistence in the rural environment (Dorresteijn et al., 2014), etc.

Geography (307) whose number of published papers ranks fifth is about the ecological and geographical environment of rural areas. A typical example of geography journals is Singapore Journal of Tropical Geography. This journal focuses on living environment and development issues in tropical areas (Wiley Online Library, 2023b). For example, land cover and fragmentation pattern in the tropical forest area (Galicia et al., 2008), riverine community vulnerabilities (Lein, 2009), and issues related to rural mobility (Turner and Oswin, 2015) were explored.

Green sustainable science technology (288) focuses on the sustainable development of rural areas. The concept of sustainable development was proposed later than the science of human settlements proposed by Doxiadis. The related research is a new attempt to improve rural human settlements based on the concept of sustainable development. Journal of cultural heritage management and sustainable development is a journal which belongs to this discipline. This journal mainly focuses on cultural heritage management and the sustainable development of cultural heritage (Emerald publishing, 2023). Relevant research includes providing design principles for developing building heritage (Hasgul et al., 2021); exploration on rural areas' response to the adaptive capacity of future extreme uncertainty (Palazzo and Bardsley, 2022) and so on.

Related research under the disciplinary background of multidisciplinary sciences (250) was done combined with multiple disciplines. The science of human settlements itself emerged under the background of multiple disciplines (Doxiadis, 1970a; Doxiadis, 1972). Exploration of the rural human settlement environment under the background of multiple disciplines can not only help to improve the rural human settlement environment by combining the advantages of different disciplines but also help to explore the essence or root causes of the science of human settlements and promote its development. The discipline classification of PLOS ONE is multi-disciplinary science journal and a lot of research related to rural human settlements were published in it. Papers on all rigorous science, including over 200 subject areas, are published on this journal (PLOS ONE, 2023). The researches published on PLOS ONE with different discipline backgrounds or even interdisciplinary backgrounds undoubtedly can promote the development of rural human settlements.

Geosciences multidisciplinary (233) focuses on the exploration of the natural environment. The journals with a big number of papers published of this subject category include the International Journal of Disaster Risk Reduction. This journal focuses on exploring the decrease of natural, social, intellectual, and technical disasters from the perspectives of different disciplines (ScienceDirect, 2023a). For example, for the multi-dimensional vulnerability assessment of rural communities (Khalid et al., 2021), in the resettlement project, different disaster factors and how to promote more reasonable settlements were considered (Parvin et al., 2022).

Related research of the subject category of urban studies (182) focuses on the research on the built environment in rural areas, including comparative studies of urban and rural environments. The representative journal of this kind is Habitat International. This journal focuses on the planning, design, management and production of urban and rural human settlements (ScienceDirect, 2023b). Related research include the evaluation of rural human settlement quality (Hu and Wang, 2020), appropriateness-dominated rural human settlement spatial optimization (Lu et al., 2020), exploration on solutions of rural depopulation and expansion of residential land (Qu et al., 2021), and perception and management of debris flow risks (Huang et al., 2020).

Under the background of anthropology (174), related research focuses on people in rural areas. In related studies, changes in rural culture, economic system, political system, art, and language were focused on. One of the representative journals is the American Journal of Human Biology. On this journal, papers related to human biology, disease and health are published (Wiley Online Library, 2023a). Related research published in this journal includes the exploration of obesity and cardiovascular diseases in urban and rural areas and the differences between the treatment of this issue in urban and rural areas (Facchini et al., 2007), exploration of the problem of lactating mothers dehydration in different rural environments (Rosinger, 2015), and the impact of tourism and economic development on the physical condition of rural children (Quinn and Childs, 2020).

3.3 The countries and regions in which papers are published

The node size in the following figure represents the number of published papers in a country or region, while the line shows the strength of cooperation between countries or regions. Different colors represent the number of published papers in different years. The nodes with country or region names in the figure are countries or regions with the number of published papers greater than 40. These countries with a large number of published papers are widely distributed in different part of the world, including a lot of developed and developing countries. This indicates that rural human settlements were focused by many scholars around the world. In general, developed countries dominate the top ten countries or regions in terms of node size (Only China and Brazil are developing countries among the top ten countries or regions in terms of node size). This indicates that developed countries or regions played a crucial role on rural human settlements research. The top three countries or regions in terms of the number of published papers are the United States, China, and England. Compared with the United States and England, the proportion of the grey area of the node representing China to the area of the entire node is significantly lower than the proportion of the grey area in the nodes representing the United States and England to the area of the entire nodes. And then, for the node representing the China, the area ratio of the yellow area is significantly higher than that of the nodes representing the United States and England. This shows that the China had a relatively small proportion of papers published from 1999 to 2013 compared with that in the United States and England, while

China had a relatively large proportion of papers published around 2022.

Related American researchers did extensive research from different aspects and promoted the better development of rural human settlements. For example, Valdez et al. (2012) studied the theme of rural food environment; Davis and Fisk (2014) explored the opinions of urban and rural residents on fracking activities related to energy production and Owusu et al. (2019) explored the intension of middle school students living in a rural environment to try to smoke. A lot of American researchers focused on the improvement of rural human settlements for the purpose of the improvement of the health conditions of rural residents. For example, McCormack et al. (2021) focused on the improvement of rural diet and physical exercise environments to respond to the problem of rural obesity; Lo et al. (2017) explored the impact of the rural environment on adults' participation in physical exercise and Parker et al. (2002) did related research on the possible related work-related injury of rural residents.

Scholars in the China also studied rural human settlements from many different perspectives such as the rural social environment, the rural economic environment, and the rural ecological environment. Tong et al. (2022) comprehensively considered a lot of different health factors and tried to explore how to build a healthier rural human settlement environment and Zhang and Zeng (2022) explored how to improve the quality of rural human settlement environment on the basis of rural revitalization strategy in China. Ye et al. (2022) focused on the evaluation index system of satisfaction with the rural human settlement environment of rural residents and the related elevation of residents. A lot of Chinese scholars comprehensively considered a lot of different factors and built index systems to explore how to improve the rural human settlement environment more comprehensively. For example, Xu et al. (2022) built an index system for the rural habitat environment of underdeveloped areas and were committed to exploring how to improve the rural habitat environment; Yang et al. (2020) built an index system for rural production, living, and ecological functions to make a better evaluation on the conditions of rural areas in these aspects; Zhou and Li (2022) built an evaluation index system for domestic water pollution assessment to improve the quality of domestic water. Compared with Chinese scholars, scholars in other countries have written relatively less papers on building of the related evaluation index system for rural human settlements.

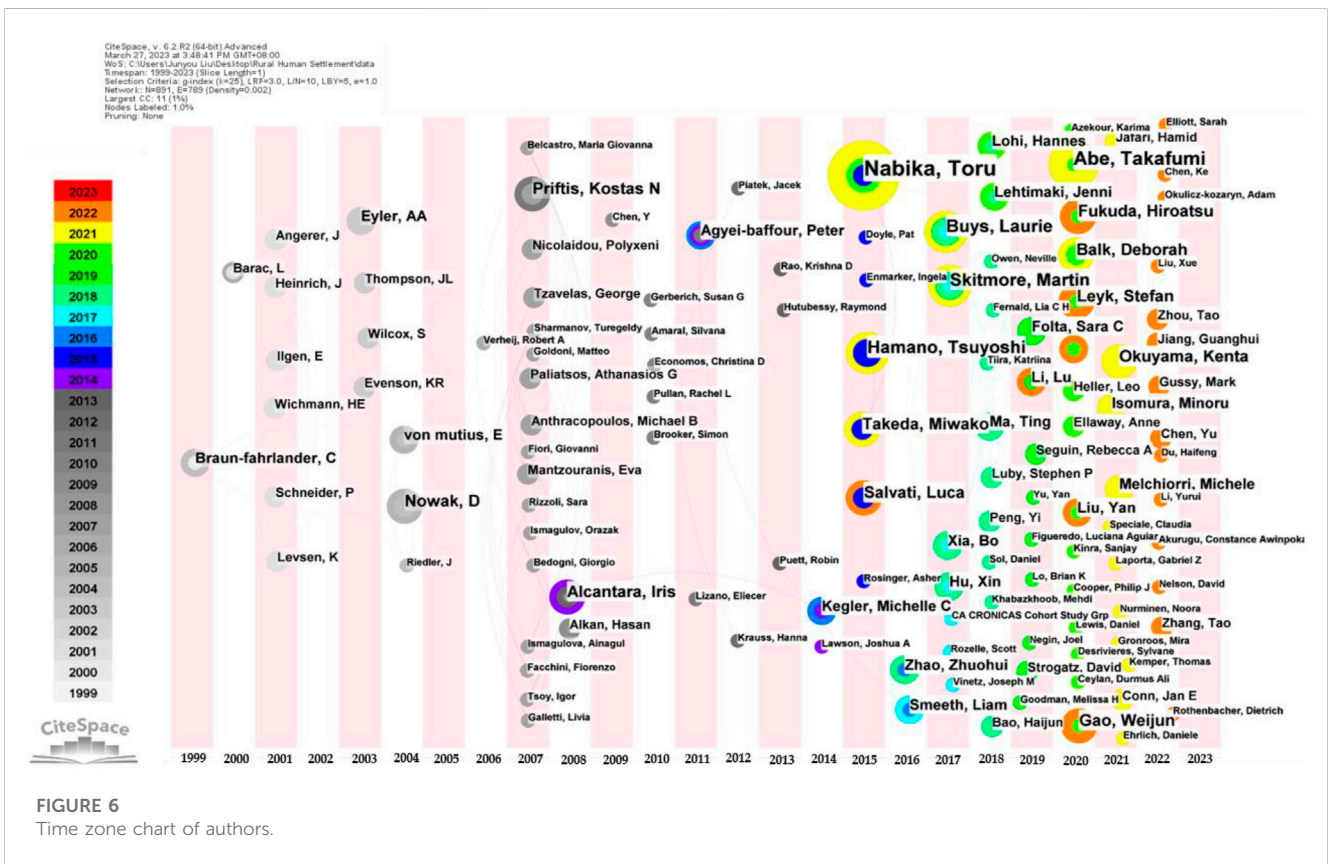
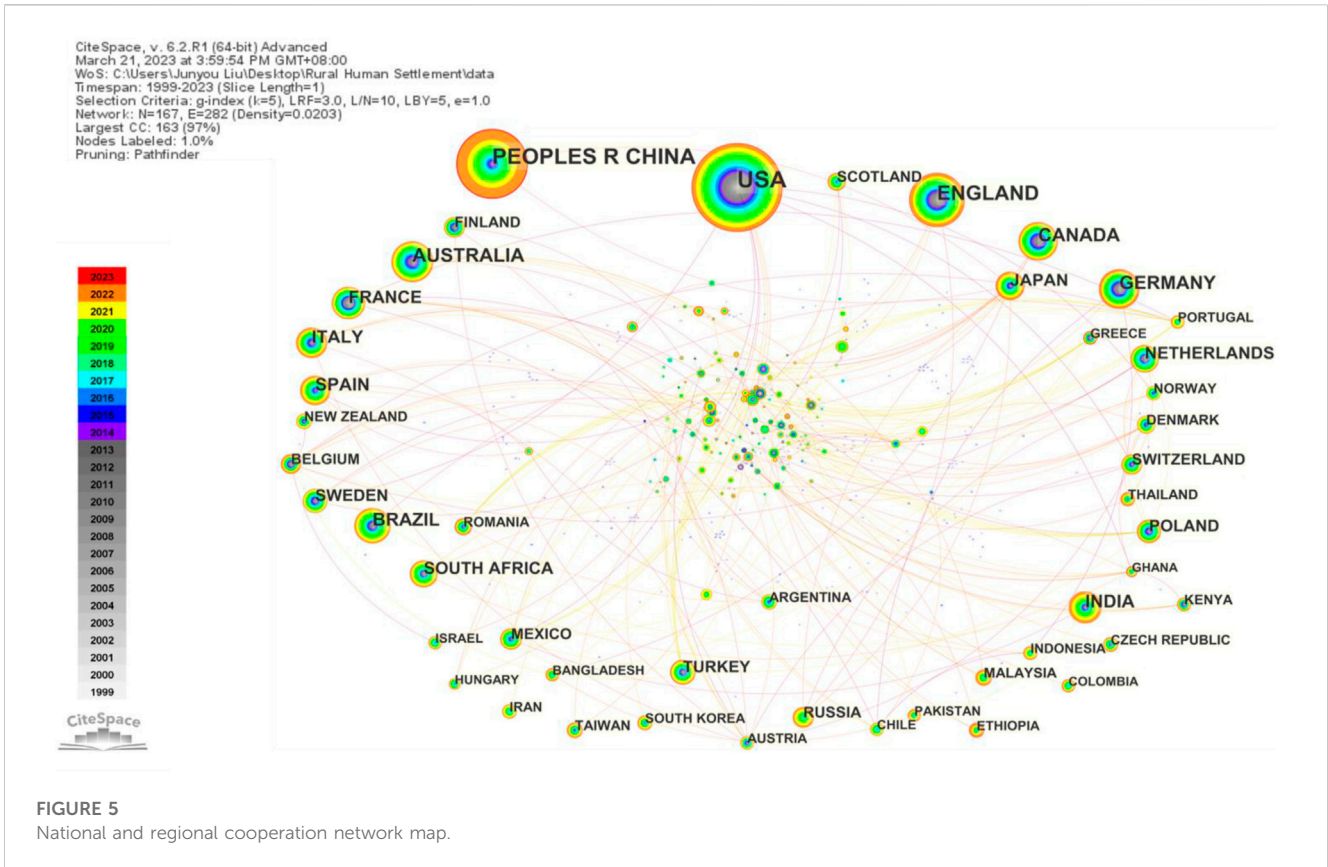
Some English scholars have also published many papers related to rural human settlements. For example, Devine-Wright et al. (2014) explored the impact of the reduction of carbon dioxide emissions produced by heating on older adults in urban and rural areas; Ogunleye et al. (2011) explored the participation in physical exercise activities and physical health of children and teenagers in different environments including cities, suburbs, and rural areas; Wadham et al. (2022) studied rural environment with the harmonious coexistence of humans and animals (horses). A lot of British scholars did related research on the environment of ancient villages. For example, Rohnbogner (2017) studied the lifestyle of rural residents, the rural environment, and the pathology of children in the Roman British period; Foxhall (2020) studied the environment of rural communities in ancient Greece; Costambeys (2009) focused on the impact of the rural settlements and taxation system on farmers in the post-Roman period.

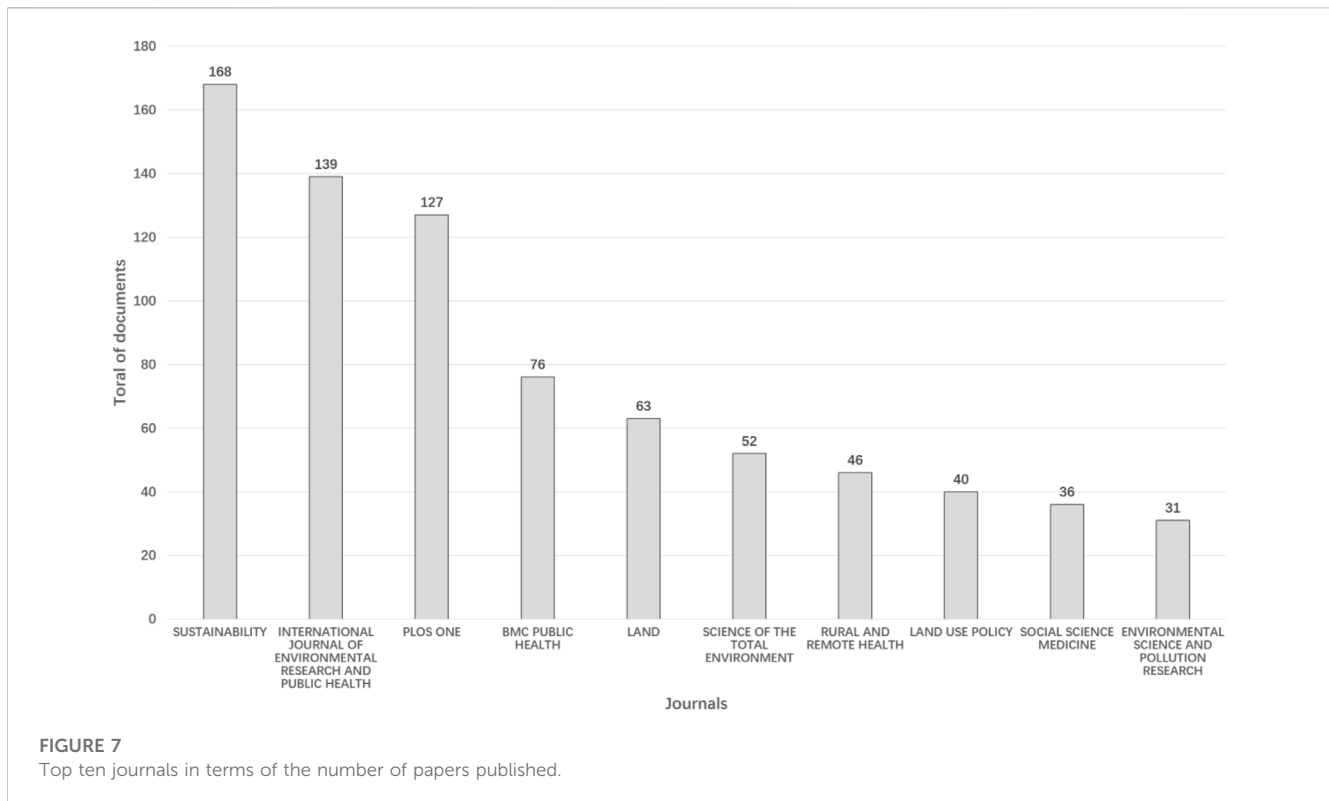
As shown in Figure 5 below, scholars from Canada, France, Germany, Australia, Italy, and some other countries and regions also have a lot of research on rural human settlements from different aspects. For example, Thomas and Jung (2019), Canadian scholars, focused on the protection of rural human settlements and habitats of wild life (an endangered bat); Kohler and Negrao, French scholars, and Marchand, a Brazilian scholar, jointly did a comparative study on the local history and landscape vitality of rural areas in France and Brazil (Kohler et al., 2015; Schneider and Holzwarth, 2021), German scholars, comprehensively studied whether rural life was healthier than urban life.

A lot of nodes representing countries or regions in Europe, North America, and Oceania have many lines. This indicates scholars from these countries and regions had close cooperations with some scholars from other countries or regions. The nodes representing China have very few lines, which indicates that relatively little research is completed by scholars in the China and scholars from other countries or regions.

3.4 Authorship analysis

Figure 6 is the time zone chart of authors, in which only some scholars who have published a lot of papers are listed. Among them, the bigger the nodes are, the more papers scholars have published. Different colors represent different time of publication. From the figure below, we could see that the number of scholars who published a lot of papers gradually increased in general from 1999 to 2023. As early as 1999, Braun-fahrländer, C who had a big number of related papers published. According to the color of this node, we could know that Braun-fahrländer, C published all related papers before 2015. By searching, reading, and analyzing Braun-fahrländer, C's research, we can know that the related research mainly focus on how to optimize the rural environment to make villagers healthier. For example, microbial transfer between rural buildings was studied (Normand et al., 2011); whether children living in the rural environment are less likely to suffer from allergic sensitization and hay fever and related factors were explored (Braun-Fahrländer et al., 2002); the impact of situational and environmental factors of children living in urban and rural areas suffering from wheezing and atopic diseases on the incidence of these diseases was examined (Horak et al., 2014), etc. Before 2010, scholars with a big number of published papers also included Nowak, D and Priftis, Kostas N. Nowak, D also did a lot of research on healthy rural areas and improving the health of residents, such as exploring the impact of participation in animal feeding activities on the respiratory health of residents (Radon et al., 2007), the impact of children's exposure to endotoxin environment on the incidence of asthma (Braun-Fahrländer et al., 1999), and whether people are more likely to suffer from Type 1 diabetes due to exposure to agricultural environment in the early years (Radon et al., 2005). Priftis, Kostas N's research mainly includes whether rural residents have better physical conditions under the precondition of more severe air pollution from traffic source in urban areas compared to that in the rural areas (Priftis et al., 2007), different impacts of different urban and rural environments on the respiratory status of school-age children (Priftis et al., 2007), and the interrelationship between the living environment, physical exercise, lifestyle, and asthma





syndromes of children at the age of 10–12 in urban and rural areas (Grigoropoulou et al., 2011). After 2014, some scholars published a lot of papers on rural human settlements, such as Nabika, Toru, Hamano, Tsuyoshi and Abe, Takafumi. Among all the scholars in the table, Nabika, Toru (with the biggest node area) has the biggest number of published papers. His earliest literature was published in 2015 and the latest literature was published in 2021. In general, the two scholars with the biggest number of published papers in the figure are Nabika, Toru (10 papers), and Abe, Takafumi (7 papers). Nabika Toru mainly studied genetic epidemiology, pathology, genetics, and physiology. A lot of research was around human health and they tried to give people a healthier living environment by improving the human settlement environment, so as to promote physical wellbeing (Hamano et al., 2015; Hamano et al., 2015; Takeda et al., 2015; Okuyama et al., 2020; Orcid, 2023a). Like Nabika Toru, Abe Takafumi was also engaged in research in the medicine and public health. He also paid high attention to rural residents' physical wellbeing and tried to improve the rural human settlement environment to improve the physical wellbeing of residents in rural areas. Besides, Nabika Toru and Abe Takafumi completed some research as co-authors (Abe et al., 2020; Fukuoka et al., 2021; Orcid, 2023b).

3.5 Analysis on journals on which papers are published

In Figure 7 below, the top 10 journals on which the most papers related to rural human settlements were published between 1 January 1999 and 18 March 2023 are listed. The number of published papers in Sustainability is the biggest, which mainly

focuses on the sustainable development of society, economy, and environment. Because the improvement of the sustainability of rural society, economy, and environment complements each other with the improvement of rural human settlements, a lot of papers in this journal are about the rural human settlement and sustainable development. The research on rural human settlements in Sustainability includes a wide range of specific sustainability issues and solutions in five different aspects including social, economic, environmental, cultural and technological sustainable development. For example, Martinez-Guido et al. (2019) tried to improve the rural living environment of disenfranchised rural communities from three different aspects including energy, water and food supply to promote better rural development; based on related policies, programming and discourse from 1918 to 2021, Venis (2022) put forward strategic suggestions on improving water, sanitation and hygiene in rural area; Akhter and Cheng (2020) explore the merits of providing rural women microcredit borrowings to empower the vulnerable group and promote rural socio-economic sustainable development.

The International Journal of Environmental Research and Public Health focuses on environmental science and human health. The articles in this journal are typically characterized by a focus on various topics related to human health (public health, environmental health, occupational health and so on). For example, Ma et al. (2019) explored the unintentional injury of rural children in their living environment and proposed relevant responses based on research; Lopes et al. (2022) explored the problem of anemia for rural resident and the associated factors that lead to anemia; Herron et al. (2021) conducted research on rural older adults isolation and loneliness feeling during pandemic, and proposed related measures to improve rural older adults social and emotional health.

PLOS ONE is a journal containing more than 200 subject areas (PLOS ONE, 2023). The total number of related published papers in PLOS ONE ranks third. To some extent, because the science of human settlement environment has developed from multiple disciplines and related comprehensive and systematic research on rural areas from social, economic, cultural, political, and technological perspectives are within the scope of rural human settlements (Doxiadis, 1970a; Doxiadis, 1972). For example, Hamano et al. (2012) explored the impact of environment and lifestyle factors on chronic hypertension of residents in remote rural areas; Toll et al. (2022) focused on the experience of consumers in remote areas during the pandemic on the emerging telehealth and carried out the research; Leisher et al. (2011) carried out the research on the balance between protecting rural native grasslands and developing rural economies.

The top ten journals in terms of the number of published papers also include BMC public health, Rural and Remote Health, and Social Science and Medicine. These three journals all focus on the environment and human health. Related articles in BMC public health include a comparative study on physical exercise and sedentary behavior for urban and rural children (McCrorie et al., 2020), relationship between the built environment and physical exercise in rural neighborhoods (Gustat et al., 2020), effects of rural home, work, and church environments on fat intake (Haardorfer et al., 2016), etc. Related articles in Rural and Remote Health include impact of rural oral healthcare programs on gingival health (Lee et al., 2017), environmental support to encourage rural villagers to participate in more in physical exercise activities (Nolan et al., 2019), seeking help when rural adolescents encounter mental health problems (Boyd et al., 2011), different degrees of obesity in urban and rural children due to living in different environments (Strochlic et al., 2017), how to make rural healthcare more accessible and affordable (Devarakonda, 2016), how to make rural residents have better access to fresh, fealth and affordable food (Miller et al., 2016), etc. Related articles published in the journal Social Science and Medicine include research on the impact of urban and rural community contexts on children's health and nutrition (Lei, 2017), differences in suffering from colorectal cancer disease in different rural settings (Beyer et al., 2011), the influence of social factors on of rural workers' motivation to work (Razee et al., 2012), etc. The improvement of the rural human settlement environment can undoubtedly help to create a healthier living environment and improve the health condition of residents.

Besides, there are also a lot of papers related to rural human settlements in journals Land and Land Use Policy, which focus on land system science and social, economic, political, legal, and planning aspects of land use (Land, 2023; Land Use Policy, 2023). Land is an important part of the rural environment. Undoubtedly, by solving the problems of rural land, we can improve the human settlement environment in rural areas. Specifically, relevant research, including the evaluation of rural living environment satisfaction (Wang et al., 2021), rural settlement simulation considering the competition in rural land use (Tian et al., 2022), suitability evaluation of living environment in rural residential areas (Yu and Xu, 2022), etc., were incorporated in the journal Land. And the relevant articles in Land use policy include rural land use change driven by rural tourism (Xi et al., 2014), exploration of the rural settlement path under balanced land use

(Gao et al., 2021) as well as the impact of rural population outflow on rural land use (Chen et al., 2014).

Science of The Total Environment and Environmental Science and Pollution Research are two journals which focus on the environment, many papers related to rural human settlements have also been published. Environmental Science and Pollution Research focuses on environmental pollution issue. This is also an important problem faced by rural human settlement environment. Science of The Total Environment includes relevant articles such as quantitative research on rural non-point source pollution in the humid low-land catchment (Yan et al., 2019), research on the benefits brought by trailbridge to rural areas (Thomas et al., 2021), research on fuel use and nitrogen dioxide emissions in urban and rural households (Colbeck et al., 2010). The relevant research can be seen in Environmental Science and Pollution Research including the impact of environmental and other health-related factors on the diversity of children's dietary habits (Otekunrin et al., 2022); study on the willingness of rural residents to use clean heat sources (Guo et al., 2022) and exploration of the use of biomass energy to promote sustainable development (Bhutto et al., 2019).

3.6 Keyword analysis

3.6.1 Keyword co-occurrence analysis

Figure 8 below shows the co-occurrence map of keywords in the literature. Each node represents a keyword. The node size represents the number of papers which includes the keyword represented by this node. That is, the bigger the node is, the higher the number of papers which includes the keyword, and *vice versa*. The line represents the degree of connection between different keywords. All nodes with a frequency of occurrence greater than 50 are marked in the figure. The big number of lines in the figure indicates that the connection between different keywords is close.

The keyword that appears most frequently is health. There is a lot of research on the strong connection between rural human settlements and human health, for example, studies on the correlation between exposure to poverty and famine and physical ill-health among poor rural inhabitants (Joffe, 2007), exploring the creation of a rural living environment with better support for stroke patients (Newell et al., 2009), studies on the spatial assessment of heavy metal contamination in garden land in rural settlements in Limpopo Province, South Africa (Kapwata et al., 2020).

Other high-frequency words closely related to human health include physical activity, objectivity, morality, disease, etc. Some researchers paid high attention to the improvement of the rural human settlement environment to encourage villagers to participate in physical exercise activities (Yousefian et al., 2009; McCormack et al., 2021). How to improve the rural human settlement environments to deal with the problem of the prevalence of obesity is also valued by many researchers. The improvement of the environment to encourage physical exercise is also a highly valued (McCormack et al., 2021). In terms of rural health human settlements, how to improve rural human settlements to decrease mortalities is also a main focus, such as a study on social needs and safety issue of rural old people (Henning-Smith et al., 2022).

The development of rural infrastructure also play a quite active role on the improvement of the livability and attractiveness of the rural area (Varahrami and Novin, 2019). Zhong et al. (2021) indicated infrastructure is one of the main factor which influence the peasants' reconstruction intention of rural settlements in Panxi area in China when rural settlement development is the key to solve rural poverty issue. According to Sikos and Szendi (2021), smart infrastructure is thought as an innovative way to improve the economy of disadvantaged rural area. Sapkota (2018) found that improving road transport, drinking water and irrigation infrastructure is quite beneficial for human wellbeing. Based on Vu et al. (2002) indicated that safe water supply and rural sanitation have a significant promoting effect on the development of agriculture in Vietnam and attracting foreign investment. Relevant water and sanitary infrastructure can promote safe water supply and rural sanitation. Bernard and Safr (2019) found in their study that residential disadvantages also exist in rural areas of Czech Republic. That is to say, residents living in rural areas will be negatively affected by the deprivation and social exclusion of their living environment. Investing in rural infrastructure is beneficial for housing development and solving housing poverty problem (Hromada and Cermakova, 2021). This can play an active role on the regeneration of the deprived areas. Urban and rural human settlements were studied as a whole or compared to each other in some studies, while some studies were based on the community scale, which is the reason why urban and community are two high-frequency keywords. There are also some risk-related studies related to health risks, natural disaster risks, and social risks. COVID-19 has seriously influenced rural areas all over the world. An increasingly number of researchers have focused on the negative impacts of the pandemic and potential risks after the pandemic. Private investment in the less developed area is risky and make those area lack of sufficient private investment. Maraseni et al. (2022) explored the impact of COVID-19 on the forestry sector of lowland region of Nepal and they think a forward-looking fiscal response with alternative income generation packages is a good option to deal with the potential social risks. Government led Afforestation Program is thought one of the win-win options for rural economic development and rural habitat protection. Some researchers pointed out fiscal decentralization is beneficial for the economic development of different countries (Morohunmubo Adeshina and Ajibola, 2020). Remote areas should look inward for revenue generation under a decentralized economic environment. Fetais and Gharib (2020) thought economic diversification is beneficial for the rural development and encourage the regeneration of old villages for the development of rural culture industry. Socioeconomic inequalities and health disparities are related and can be focused together. Apostolopoulos et al. (2018) explored the health disparities suffered by ethnic minorities who lived in the deprived rural area.

3.6.2 Keyword citation burst analysis

The burst words can be used to explore emerging trends and abrupt changes in the related studies (Figure 9). Hay fever and asthma emerged from 1999 to 2010 and from 1999 to 2009, respectively. This indicated that research focusing on the relationship between rural human settlements and human health suddenly appeared in this period. Among them, hay fever and

asthma were paid the most attention by researchers. Besides, children was a burst term from 1999 to 2012 and childhood was a burst term from 2001 to 2008. They both indicate that some of the researchers studying rural human settlements in this stage paid more and more attention on improving rural human settlements based on the demands of children as a vulnerable group. For example, Riedler et al. (2000) explored whether Australian children living in rural areas had less hay fever, asthma, and allergic sensitization.

Risk appeared as a high-frequency word from 2001 to 2006, which indicated studies on the risks of rural human settlements significantly increased in this period. For example, Korf (2003) explored the conditions of war-affected rural community and the risks faced in lives of villagers.

Similarly, the burst words, which were connected to physical conditions (overweight, body mass index and obesity), emerged from 2008 to 2014, from 2009 to 2016, and from 2010 to 2015, respectively. The occurrence of these burst words indicates that there was a significant increase in research on the connection between rural human settlements and overweight or obesity during this period. For instance, Janitz et al. (2012) studied whether white and American Indian students living in the same rural environment had different obesity rates and related reasons.

The burst terms that have appeared in recent years include sustainability (2020–2023), ecosystem services (2018), settlement (2020–2023), and rural revitalization (2021–2023). The emergence of ecosystem services and sustainability from 2018 to 2023 and from 2020 to 2023 also indicated that rural ecology and social and economic environment were paid more and more attention, especially their sustainability, in recent years. For example, Liasidou et al. (2021) studied the impact of the tourism industry on rural society, and promoted the sustainable development of the rural areas in this regard. After rapid urbanization in a lot of developing countries, rural areas not only developed slowly but also lagged behind cities in many different aspects. For better development in rural areas, some researchers studied rural revitalization. For example, Shen and Chou (2021) explored cultural landscape development in the process of rural revitalization.

3.6.3 Keyword cluster analysis

In Figure 10 keyword clustering map below, keywords were classified, which can help to have a more comprehensive understanding of the related keywords. Most studies in the clusters of #0 physical activity, #1 asthma, and #3 mortality are closely related to human health. Physical activity is undoubtedly good for the health of rural residents. A lot of researchers studied how to encourage and support villagers to participate in physical activities by improving the rural environment (Yousefian et al., 2009; Dalstrom et al., 2021; McCormack et al., 2021). #1 asthma is mainly about the impact of rural human settlements on patients with asthma or asthma prevention in rural living environment. For example, Bedolla-Barajas et al. (2018) explored whether there were related protect factors in rural environment that could effectively protect children from asthma and other allergic diseases. They did the research with children living in different rural and urban environments in Mexico as an example, in which they did not find that related protect factors could decrease the incidence of related diseases among rural children. #3 mortality is a

Top 20 Keywords with the Strongest Citation Bursts



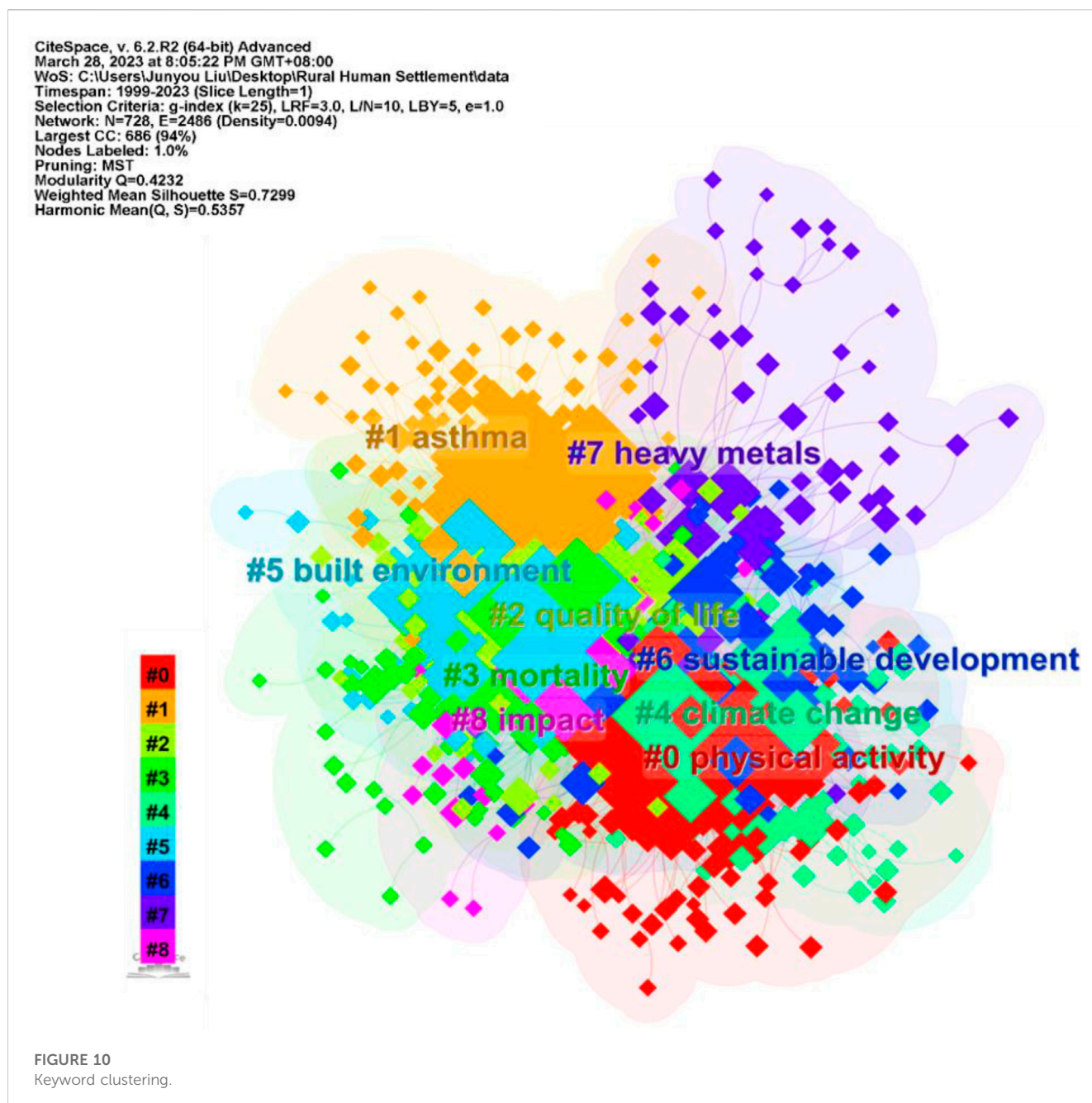
FIGURE 9
Keyword emergence.

main cluster. It concentrates on the impacts of some adverse factors in rural human settlements on the mortality rate. For example, [Mestl et al. \(2006\)](#) explored the impact of the use of solid fuel in urban and rural life on the mortality rate of residents.

#6 Sustainable development is an important cluster. It indicates that some researchers focused on the application of sustainable development concept in the improvement of rural human settlements. For example, [Wang and Chiou \(2019\)](#) studied the sustainability of human settlement space environment of traditional villages. Global climate warming also has a significant negative impact on rural human settlements. Some researchers also studied how to improve the rural environment to respond to climate change. For example, [Horton et al. \(2010\)](#) studied the health risks of old people due to climate change. Heavy metal can not only have a significant negative impact on the environment but also seriously affect the physical health. Some researchers studied heavy metal pollutions in rural areas and their negative impacts. For example, [Babayán et al. \(2019\)](#) studied the water quality and health of residents in areas seriously affected by the mining industry. The improvement of the built environment is undoubtedly an important part of improvement of the rural human settlement environment. A lot of researchers did such studies. For example, [Zhang et al. \(2020\)](#) studied the impact of the obesogenic environmental factor on the

rate of obesity in urban and rural built environments. An important purpose of the improvement of rural human settlements is to improve the quality of life of residents. For example, [Kanji et al. \(2012\)](#) tried to explore effective means to improve the rural environment and quality of life of residents from different aspects such as local governance, infrastructure development, and cross-border development.

By improving the rural human settlements, we can improve the quality of life. This was also valued by a large number of researchers and they regarded this as a main study theme. People can have a healthier living environment by improving the rural human settlements and the residents' quality of life at the same time. When proposing the science of human settlements, Doxiadis, the founder of the science of human settlements, paid high attention to the relations between humans and society, nature and built environment ([Doxiadis, 1970a](#); [Doxiadis, 1972](#)). Rural housing is an important part of the rural built environment. The research on rural housing not only highlights the function, spatial settlement structure and landscape aesthetics but also values the importance of more affordable rural housing from the perspective of rural housing supply and demand ([Bański and Wesołowska, 2010](#); [Borgersen, 2019](#); [Buonfiglio, 2022](#)). For example, [Bański and Wesołowska \(2010\)](#) explored strategies to improve Poland's Lublin region

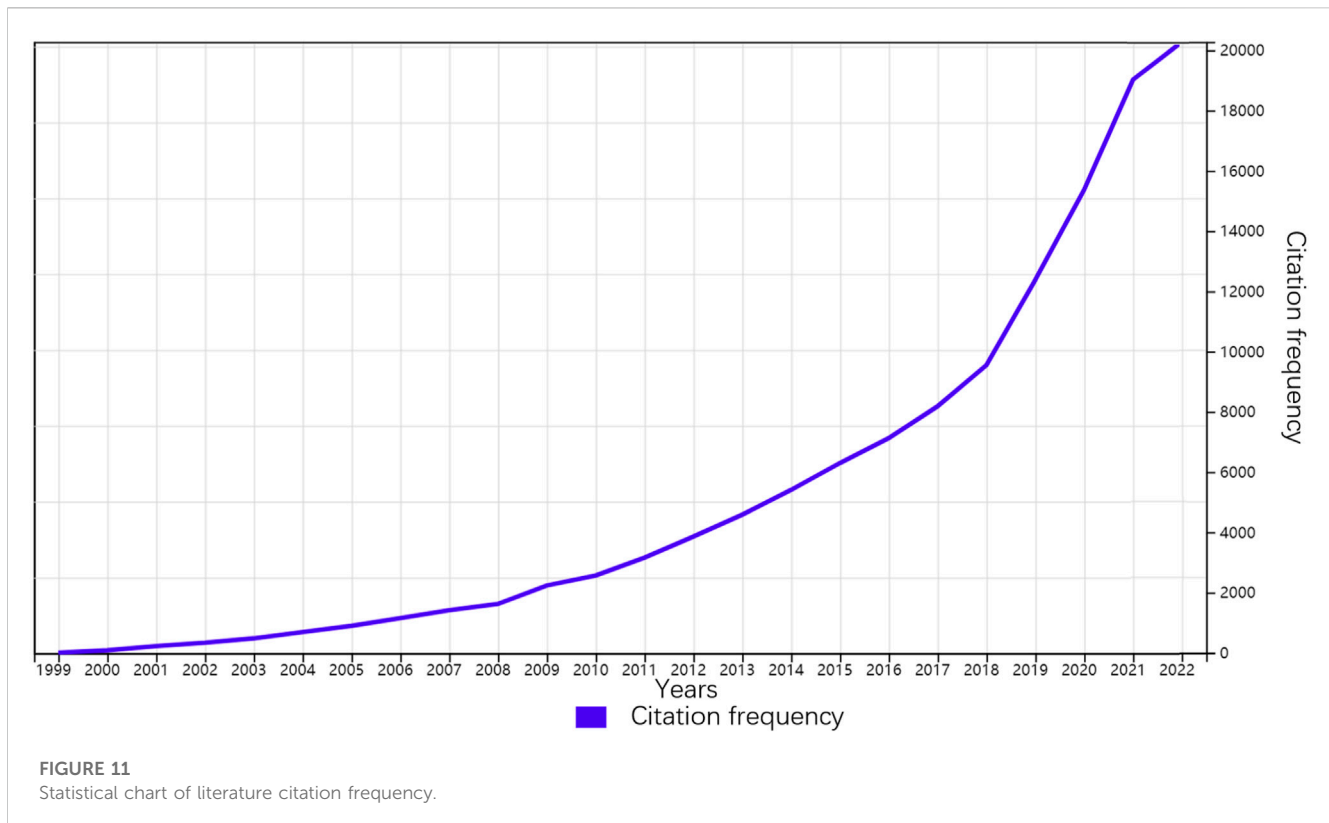


rural housing from the perspective of spatial settlement structure and landscape aesthetics; Li et al. (2022) study the thermal comfort and energy efficiency of rural building environments in China. Many villages are located in less developed areas and these areas can suffer from a deeper magnitude of real estate price cycle and slower overall economic recovery (Hromada et al., 2023). Özkuvanci and Alkiser Bregger (2019) explored the changes in the quality of life of villagers in new rural residential areas caused by the implementation of TOKI Tarimkoy's macro scale development strategy in the Balikesir region (Marmara region) Turkey. Buonfiglio (2022) explored the impact of the National Rural Housing Program on rural housing in Brazil. This project played an important role in providing more affordable and accessible rural housing. Improvement of rural human settlements can undoubtedly

promote rural sustainable development. Some scholars focused on improving the rural human settlement environment and contributing to the global sustainable development goals. Papers about heavy metals focus on the problem of heavy metal pollution in rural areas and improvement strategies. Undoubtedly, the rural human settlements can be improved by rural pollution control.

3.7 The number of citations

The number of citations of the papers can show the extent to which the rural human settlements related research is valued. From Figure 11 below, we could see that the number of citations of related literature on the rural human settlements. From 1999 to 2008, this



shows slow growth. In 2008, the number of citations was less than 2,000 in the whole year. From 2009 to 2018, the number of citations was in a period of stable growth. The number of citations increased from less than 3,000 times in 2009 to slightly less than 10,000 times in 2018 in the last 10 years. From 2018 to 2022, the number of citations increased fast and the number of citations doubled in these 4 years. In 2022, the number of citations reached 20,000 times. Because the data was exported on 18 March 2023, without data of the whole year, we could not know the number of citations in the whole 2023. Thus, we did not include the number of citations in 2023 in Figure 11. This also indicates that rural human settlements were increasingly valued by many scholars, especially in recent years.

Table 1 shows top 5 most highly cited papers. In 2010, Impact of diet in shaping gut microbiota revealed by a comparative study in children from Europe and rural Africa published on the journal of Proceedings of the National Academy of Sciences of the United States of America was cited in 3,494 papers. Its number of citations ranked first in all related literature. In this paper, it is pointed out that we can protect children from being affected by inflammation and non-infective colon diseases by protecting the treatment of microbial diversity from infectious rural communities (Braun-Fahrlander et al., 1999). The number of citations of Environmental exposure to endotoxin and its relation to asthma in school-age children published on the medical journal New England Journal of Medicine in 2010 ranked second. The total number of citations was 1,348 times. Researchers explored the relationship between exposure to etoxin and asthma in the environment with rural children in Germany, Austria, or Switzerland found that exposure to this environment could increase their tolerance to allergens (Braun-Fahrlander et al.,

1999). The number of citations Green space, urbanity, and health: how strong is the relation? Published on Journal of Epidemiology and Community Health in 2006 ranked third. It was cited in up to 1,091 papers. In this study, it was found that there was a positive association between the ratio of green space and the health condition of urban and rural residents in urban and rural human settlement environments (Maas et al., 2006). The number of citations of the article A global analysis of human settlement in coastal zones published in 2003 ranked fourth (980 times). In this paper, the conditions of global coastal regions are analyzed and it is found that the population density of global coastal zones is three times higher than the global average population density. Most near-coast population lives in rural areas and small-to-medium-sized cities, rather than big cities (Small and Nicholls, 2003). The number of citations of the article Anthropogenic transformation of the biomes, 1700 to 2000 ranked fifth. This study revealed that there was no human settlements on nearly half of the terrestrial biosphere on earth in 1700. Since then, rangelands, croplands, and villages grew fast. By 2000, the biosphere only had less than 20% seminatural and only a quarter left wild (Ellis et al., 2010).

4 Discussion and trend analysis

As shown in the Ekistic Grid proposed by Doxiadis (Figure 1), he emphasized that the human settlements should be studied generally, systematically, and comprehensively as a whole from aspects such as politics, economy, society, culture, and technology (Doxiadis, 1970b). Although some scholars had written some review articles on some aspects of rural human

settlements, these articles did not comprehensively sum up the relevant research on rural human settlements based on a interdisciplinary understanding. Wei et al. (2023) conducted a comprehensive review of the relevant researches about the improvement of rural living environment in China during 1992–2022. Obviously, this literature review focused more on the situation of rural living environment improvement in China, rather than a worldwide review. Similarly, Stone et al. (2022) summarized the impact of Latino rural built environment on residents' health. In addition, Ao et al. (2020) studied the impact of rural built environment and the changes it brought on residents' travel activities. Li and Song (2023) made a comprehensive review of relevant studies on rural settlements in 1973–2021, which focused on rural housing and rural residential. Love et al. (2019) summarized papers about the impact of rural food environment on residents' health status. It is apparent that these literature reviews stressed one certain aspect of rural human settlements instead of focusing on rural human settlements as a whole. In this study, we tried to summarize related literature from the interdisciplinary perspective in the last 25 years and promote the better development of the science of human settlements.

In the process of quantitative analysis of literature related to rural human settlements, we found that the studies related to rural human settlements covered different aspects but many studies were about the relationship between rural human settlements and human health. A lot of keywords related to human health emerged, many authors who had published a big number of papers studied rural human settlements and residents' health, and many frequently cited papers were related to residents' health. On the one hand, this shows that people pay high attention to the physical conditions of residents living in rural human settlements. On the other hand, it also shows that rural villagers still face many health problems. According to Maslow's Hierarchy of Needs Theory, physiological needs and safety needs are the two lowest levels (Maslow, 1943). To meet the needs of residents at the two levels, a lot of problems should be solved and it should be significantly improved. On the contrary, there are few studies on communication, respect, aesthetics, and self-realization of rural residents. From the perspective of Maslow's Hierarchy of Needs Theory, with the constant development of rural society, the needs of rural residents constantly increase, and studies on high-level needs of rural residents in the rural environment other than adequate food and clothing and health will gradually increase. On the other hand, more researchers can focus on improving the rural environment to meet the needs of rural residents for communication, respect, aesthetics, and self-realization. This can help with better development of rural human settlement environment and meet the needs of residents.

Through quantitative analysis of literature related to rural human settlements, we can find that there are relatively less studies on improving the rural human settlement environment through rural economic and cultural development. There are also only a few studies on improving the rural human settlement environment by improving infrastructure such as rural roads, electricity, and flood control. This shows that many related researchers only focused on the rural ecological environment and health of rural residents (as can be seen from information such as subject categories, journals, and high-frequency keywords). Rural economic and cultural development should be paid more attention

to. To some extent, this is also because some scholars studied rural economy and culture fail to incorporate their studies into the context of the science of human settlement environments. Rural economy is studied from the perspective of a single discipline such as economics. Rural residents live in a complicated environment and we should make efforts from different aspects to improve the rural human settlement environment. We summarized the related papers on rural human settlements in the last 25 years. We advocated related scholars to treat the issues of rural human settlement environment as a part of the science of human settlements, and pay attention to its relation with other aspects.

Scholars from different countries around the world did extensive research on different aspects of rural human settlements. In general, more studies were done in developed countries. In developing countries, related studies were done relatively late and there were relatively less related studies. The studies from different countries are similar. That is, the studies done in each country cover many different aspects and most of the studies focus on hot topics such as improving the rural ecological environment and healthy rural human settlement environment. Scholars from different countries have some unique characteristics in the study of rural human settlements according to their national conditions. For example, the total number of studies conducted by American scholars on improving rural human settlements to improve the physical health of residents was significantly bigger than that in most other countries; a lot of British scholars studied historical villages of the rural human settlement environment. A lot of Chinese scholars paid attention to rural revitalization and comprehensive evaluation of the rural areas by building indicator systems.

In recent years, an increasing number of scholars have focused on the development of evaluation index systems to evaluate some specific aspects of rural areas so as to achieve the goal of rural human settlement improvement (Chen and Mak, 2021; Liu et al., 2022; Wang et al., 2022; Xu et al., 2022; Xu and Sun, 2022; Ye et al., 2022; Hu et al., 2023). Hu et al. (2023) constructed a data-driven evaluation framework to evaluate the effect of Chinese rural revitalization strategy on villages in Hubei. Their study was conducted on six different aspects of thriving business, pleasant living environment, social etiquette and civility, effective governance, living in prosperity and organization system. By means of the indicator system, they evaluated the villages of 13 prefecture-level and 83 county level regions of Hubei province, China and found that there is a regional agglomeration and differences in various dimensions. Regions with policy support or featured industry perform better (Hu et al., 2023). However, in contrast to the comprehensive approach of Hu et al. (2023), who constructed an assessment index system around six different aspects of rural revitalization, Wang et al. (2022) put more emphasis on one aspect of assessing the effect of integrated development of village agriculture and tourism on rural ecology. They constructed an assessment index system accordingly. Their assessment on villages in 19 provinces within the Yangtze River Economic Zone and Yellow River Economic Zone in China revealed a gradual improvement in the ecological quality of the villages in the study area from 2007 to 2019. In the same period, an upward trend of agriculture-tourism integration was also observed in the study area. The integrated development of agriculture and tourism is positively correlated with rural ecological environmental quality. In other

word, increase the integrated development level of agriculture and tourism is beneficial for the improvement of rural ecological environmental quality. Xu et al. (2022) constructed an evaluation index system from three system layers: rural production settlement, rural living settlement and rural ecological settlement, to evaluate spatial-temporal features of rural living environment in mountainous regions of Zhejiang Province, China. Due to their location on the periphery of some economically developed centers, rather slow economic development and complex terrain topography, these rural areas are less accessible and have a more obvious development disadvantage. Thereby, a targeted index system around these areas is necessary for improving the rural living environment in these remote areas. According to the assessment of rural human settlements in mountainous regions of Zhejiang Province based on a targeted index system, they found that rural human settlements in mountainous regions of Zhejiang Province showed a gradual improvement trend. There were significant differences among the results of assessment on villages in different regions by applying the index system; policy orientation affected rural human settlements significantly, and two factors that had the most significant impact on rural human settlement were agricultural modernization and economic development level. According to Vaani and Sekar (2012), the conclusion that some villages and 1,235 km of roads are vulnerable to landslides were finally identified after an indicator system was developed by them to determine the landslide hazard zone map for the region of Nilgiris of India, taking into account the factors of rainfall, geology, land use and slope. Such successful application of the assessment framework also justifies the importance of the use of relevant assessment indicators. In addition, in a review of various papers, Ghosh and Mistri (2022) constructed an indicator system that includes 25 indicators in terms of exposure, sensitivity and adaptive capacity to explore the vulnerability and existence of various hazards in the Matla-Bidya inter-estuarine area in India. Their assessment showed that villages in the western and southern parts of the study area were extremely vulnerable to multi-hazards such as cyclone, flood and inundation, villages in the central part of the study area showed moderate vulnerability to multi-hazards, and villages in the upper part of the study area suffered from high inundation risk. As described above, such indicator system can also be applied to coastal areas with similar conditions worldwide to guide the identification of the vulnerable area and relevant hazards. This will help people to take effective measures to deal with the relevant hazards in a timely manner with a comprehensive understanding of the relevant hazards. Constructing index system is beneficial for the understanding of rural human settlements and exploring the optimization path from different aspects, thus optimizing the rural human settlement. This paper argues that seeing rural human settlement as a whole from the perspective of the science of human settlements and carrying out comprehensive studies on rural human settlements are conducive to better understanding the advantages and disadvantages of rural human settlements and making targeted improvement strategies. As researchers usually develop indicator systems relating to rural human settlements based on extensive reading of the relevant literature (Chen and Mak, 2021; Liu et al., 2022; Wang et al., 2022; Xu et al., 2022; Xu and Sun, 2022; Ye et al., 2022; Hu et al., 2023), such a review of research

on rural human settlements in this study will not only help readers understand the relevant literature in the past 25 years but also provide guidances to researchers who wish to develop assessment indicator systems for rural human settlements in a more scientific and rational manner in light of the progress of relevant research.

In the last 25 years, studies on rural human settlements gradually increased. First, most countries in the world, especially developing countries, experienced rapid urbanization in recent decades, after which people would gradually feel that urban and rural areas did not have the relation of binary opposition and they should develop in a coordinated way and gradually pay more attention to rural human settlements. Besides, with globalization, more and more scholars around the world will publish papers which studied rural human settlements in related journals. More related studies will also lead to an increase of the numbers of reading and citation of previously published literature year by year. Because themes such as improving the rural ecological environment and building a healthy rural human settlement environment have great practical significance, such papers may still account for a big proportion of publications in the next decade or longer time. With the improvement of the conditions of material life of rural residents, more and more scholars will do more in-depth studies on improving the rural cultural environment and meeting demands for communication and self-realization of rural residents. Because different countries around the world have different national conditions and policies, scholars may have different focuses when they conduct studies on rural human settlements. The extent to which scholars are affected by Doxiadis and the science of human settlements will be significantly different because scholars from different countries live in different environments.

5 Conclusion

Based on the condisciplinary thinking of human settlements proposed by Doxiadis, an overview was conducted for rural human settlements. This review includes related literature in the database of the Web of Science in the last 25 years. The purpose is to encourage related researchers to treat the rural human settlements with condisciplinary thinking and strive to improve it. From the related papers in the review, we found that researchers focused on improving the rural ecological environment and creating a healthy rural human settlement environment in the past and they should pay more attention to high-level needs such as rural cultural environment, social interaction of residents, and self-realization. We believe that we can do more comprehensive studies from the perspective of the science of human settlements rather than from the perspective of a single discipline such as economics, sociology, and urban and rural planning. Building an evaluation index system related to rural human settlements is beneficial for the evaluation and development of rural human settlements. Because different countries have different national conditions, researchers focus on different aspects of rural human settlements. Related policymakers should treat rural human settlements with condisciplinary thinking so that scholars can study and improve rural human settlements as a whole. In this way, scholars from different countries in the world can have a better understanding of it and integrate into the science of human settlements.

Author contributions

JL: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing—original draft, Writing—review and editing. BZ: Conceptualization, Data curation, Methodology, Project administration, Supervision, Writing—review and editing. HT: Formal Analysis, Writing—original draft, Writing—review and editing.

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Conflict of interest

HT was employed by China Machinery International Engineering Design and Research Institute Co., Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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