

Review

# A Bibliometric Review of Rural Living Environment Improvement Research in China Based on CNKI Database: 1992–2022

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**Abstract:** Improving the rural living environment has become one of the hot issues in the study of rural revitalization in China. Based on 972 high-quality journal articles, in the database of China National Knowledge Infrastructure (CNKI), this paper provides a detailed bibliometric review of research on the improvement of the rural living environment in China, from 1992 to 2022. Based on a descriptive statistical analysis of the publication trends, authors, institutions, source journals, and high-frequency keywords of the sample literature, this paper uses cluster analysis and multidimensional scaling analysis to quantitatively analyze the main research fields, hot topics, and improvement directions. The results show, that the study of the improvement of the rural living environment presents a good trend. The main research include six aspects: rural sewage improvement, rural waste management, rural environment collaborative treatment, rural toilet improvement, new rural construction and management, and rural environmental green development. Among them, the research heat and abundance of research results of the first three, is higher than the latter three. To further deepen the research related to the rural living environment improvement in the future, issues such as rural toilet improvement, new rural construction and governance, and green development of rural environment, need more attention.

**Keywords:** bibliometrics; rural living environment improvement; social network analysis; cluster analysis; multidimensional scaling analysis; China



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## 1. Introduction

The rapid development of the global economy has brought serious environmental pollution problems, which significantly threaten the living environment of human beings. It is urgent to improve our living environment [1]. The concept of human settlement was first proposed by Doxiadis in the 1950s, who divided the concept into urban settlement and rural settlement. Doxiadis believed that rural settlement is the closest and most specific geographical space for material exchange and emotional communication between human beings and the environment, as well as the regional arrangement made by human beings to meet their survival and development needs [2].

The United Nations held three conferences on the human living environment in 1976, 1996, and 2016. These conferences adopted the Vancouver Plan of Action, the Istanbul Declaration, the Habitat Agenda, and the New Urban Agenda. These declarations or agendas, committed to constructing sustainable human settlements with adequate shelter for all, explicitly put forward the sustainable view of human living environment development [3]. The UN Sustainable Development Summit adopted the 2030 Agenda for Sustainable Development, in 2015. The agenda renews “building inclusive, safe, resilient and sustainable cities and human settlements”, as one of the development goals [4].

In 2020, China had a total population of 1412.12 million. The rural population was 509.92 million, accounting for 36.11 percent of the total. This ranks among the highest in the world. This reality has determined that improving the rural living environment in China, has become a hot topic of political concern and academic research [5]. The CPC Central Committee and the State Council, respectively, implemented the Three-year Action Plan for Improving Rural Living Environment (2018–2020), in 2018 [6], and the Five-year Action Plan for Regulating and Improving Rural Living Environment (2021–2025), in 2021 [7]. Both documents regard improving the rural living environment as essential in enhancing the rural ecological environment and promoting a rural revitalization strategy. At the 20th National Congress of the Communist Party of China, in 2022, the Chinese government once again stressed the importance of improving environmental infrastructure and the rural living environment.

Domestic and foreign scholars have done a lot of research in the field of rural living environment improvement. This mainly focuses on the strategic policy level, efficiency evaluation of environmental governance, predicament identification, and the exploration of paths towards rural living environment improvement. The current research on the status quo, hot spots, and trends needs to be extended. In summary, it is necessary to systematically review the journal articles on improving the rural living environment in China. In this way, we can effectively highlight the research progress and probe the research topics' internal links and development rules.

Therefore, this paper, based on the China National Knowledge Infrastructure (CNKI) database, the largest database of academic papers in China, selected 972 Chinese journal articles on the remediation of rural human settlements in China for quantitative analysis, aiming to answer the following questions:

- (1) What are the trends in the number of articles published in the field of rural living environment improvement, in China?
- (2) What are the characteristics of the authors, institutions, and source journals?
- (3) What are the main fields and the key contents of the research?
- (4) What are the research hotspots and future directions?

This study includes six parts: introduction, literature review, data and methodology, results and analysis, discussion, and conclusions. Firstly, this paper clarifies the research background and leads in to the research questions in the introduction. Secondly, this paper reviews the existing literature and expounds on the research progress and shortcomings in this field. Then, descriptive statistical analysis is carried out on the publication trends, authors, institutions, and source journals of the sample literature. On this basis, this paper identifies high-frequency keywords and carries out social network analysis. Then, according to the previous results, the paper identifies the main contents and hot topics of this field and summarizes the research achievements of scholars. It will help to clarify the direction of future research. Finally, this paper presents a summary and conclusions.

## 2. Literature Review

Urban and rural areas are in the same ecosystem, and the development of both must go hand in hand [8]. However, compared with urban areas, the living environment in rural areas is relatively low, which endangers overall health sustainability. It is urgent to improve the rural living environment globally.

The quality of the rural living environment is closely related to the health status of residents. Elholm et al. found that high exposure to endotoxins in agriculture, was associated with less sensitization of new pollen [9]. Jonsson et al. explored whether food could regulate allergy rates in children in a farm setting [10]. Braun-Fahrlander et al. found that exposure to environmental endotoxins in preschoolers, influenced tolerance to asthma allergens [11]. Martin made a detailed comparison of the differences in oral health among older people from urban and poor areas [12]. Erin et al. pointed out that drinking water in rural areas is largely untreated, due to poor infrastructure. This will lead to a build-up of cryptosporidium and giardia, which can affect human health. Rural

villagers are much more likely to get sick than urban residents [13]. In addition, rural living environment conditions will also affect the growth and development of children. Yeonwoo et al. found, through comparative analysis, that the neighborhood living environment affected the physical activity of poor children. Children living in non-poor and unequal communities have fewer opportunities for physical activity, which may affect their physical development [14]. David et al. used structural modeling to assess the impact of health infrastructure, personnel, and services on child nutrition in rural Nepal [15].

Previous research has shown that the government and society are committed to improving the rural living environment, not only because it is related to the achievement of sustainable development goals, but also because it is of personal interest to everyone. However, the current situation of the rural living environment is not good. Chen evaluated the geographical components of natural ecology and the natural suitability of the living environment in Shanxi. The results show, that only a small percentage of counties in Shanxi Province have a suitable living environment [16]. Guo set one first-level indicator, three second-level indicators, and ten third-level indicators, to evaluate the ecological environment quality in rural areas of Liaoning Province, from 2015 to 2018. The results show that the local ecological environment quality has gradually improved, but it is still under great pressure [17]. Based on a structural equation model, Zhao et al. conducted a qualitative and quantitative evaluation of the rural hard and soft living environment in six provinces and cities in China. The results showed, that the surveyed farmers were less satisfied with the local rural living environment [18]. On the whole, the improvement of the rural living environment in China has been achieved to some extent, but there are still many problems. Summarizing the problem is of great benefit to its future management. Therefore, it is necessary to review and analyze the research in this field. A literature review is considered to be an effective way to deeply understand the field of research [19].

Over the past few decades, scholars have increasingly focused on research on the improvement of the rural living environment, and have produced an increasing number of papers [20]. It is difficult to review thousands of papers using traditional methods [21]. To solve this problem, many scholars began to use scientometrics software [22]. To date, several researchers have carried out a quantitative and objective analysis on the field of rural living environment improvement, with the help of visual tools. Zhang et al. performed a visual analysis of the research status in the field of the rural environment and health, with CiteSpace and Ucinet. This provided important knowledge support for researchers to carry out follow-up research. However, their sample literature was from 2000 to 2017, ignoring the initial period of China's rural living environment improvement research [23]. Wu et al. conducted a bibliometric review of studies on rural ecological issues in China from 2013 to 2022. This paper quantitatively analyzes the hot spots and key contents in this field, which could provide some inspiration for future environmental governance. However, the paper could have used more visual tools to present the results, rather than just statistical graphs. These are not conducive to a clear presentation of research results [24].

This paper attempts to extend the previous studies and supplement the research gaps in this field, through bibliometric analysis. We use SPSS, Bicom, Ucinet, and Excel to analyze 972 studies in the CNKI database, from 1992 to 2022. The focus of this study is to review the research on the rural living environment improvement in China, and look forward to future research. It will not only help China to achieve ecologically sustainable development, but also provide experience for the improvement of the rural environment in other countries around the world.

### 3. Data and Methodology

#### 3.1. Data Sources

The China National Knowledge Infrastructure (CNKI) database, is the largest database of academic papers in China. It contains more than 7000 scholarly journals, including Chinese literature, foreign literature, academic dissertations, newspapers, conferences, yearbooks, reference books, and so on [25]. Its primary function is to provide unified

search, navigation, online reading, and download services for readers at home and abroad. The data sources of this paper are the Core Journal database, the Chinese Social Sciences Citation Index (CSSCI) database, and the Chinese Science Citation Database (CSCD) in CNKI. The earliest literature on the subject in these databases dates back to 1992. It is for this reason that we set the time frame of this review.

In 2018, the General Offices of the CPC Central Committee and The State Council issued the Three-year Action Plan for Improving Rural Living Environment. According to the plan, the main tasks of the improvement of the rural living environment include promoting the treatment of rural household garbage, carrying out the treatment of toilet feces, promoting the treatment of rural domestic sewage by steps, improving the appearance of villages, strengthening village planning and management, and improving the construction and management mechanisms [6]. Based on these tasks, this study determines the search keywords, presented in Table 1.

**Table 1.** Summary of search details.

Retrieval Condition Category	Retrieval Condition Setting
Retrieval mode	Advanced search
Retrieval pattern	Precise
Searching terms	Ti = ("rural living environment" or "rural environment improvement" or "rural waste management" or "rural sewage treatment" or "rural toilet improvement" or "village looks")
Literature type	Chinese periodical
Years	1992–2022
Source category	Core Journal, CSSCI, CSCD

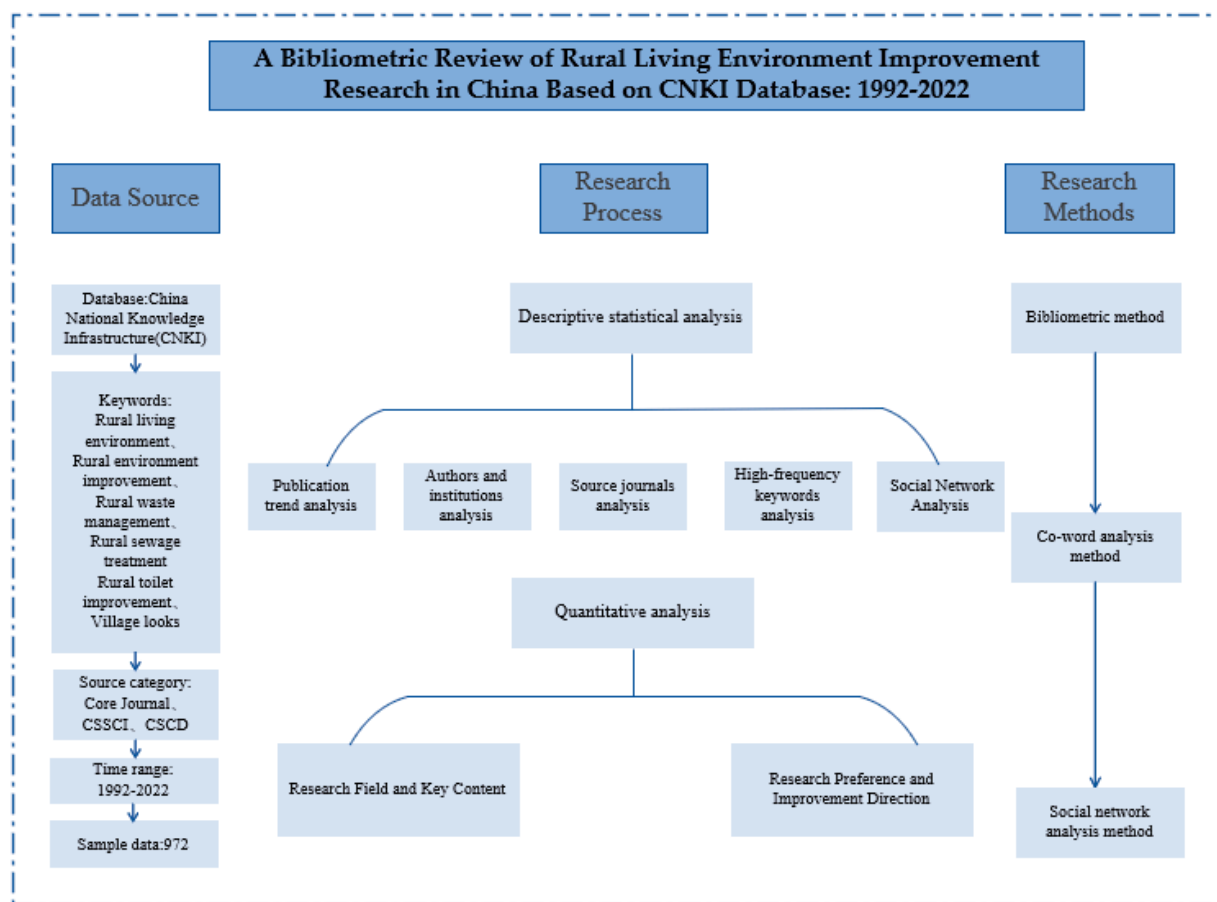
Based on the above, a total of 1404 pieces of data were retrieved. The data that do not meet the visualization requirements, such as duplication of incomplete information in the title catalogue, policy announcement, news, and work overview, were filtered out [26]. Finally, this paper obtained 972 valid data.

### 3.2. Research Methods

Bibliometrics can quantitatively analyze the external characteristics of a large body of literature, to identify the research status, knowledge structure, development trends, and research frontiers of a field [27]. This study used bibliometrics to analyze the sample literature on rural living environment improvement in China. It also utilized tools to display the research results visually. Figure 1 shows the data collection and research process of this paper.

The details are as follows:

- (1) Analysis of the basic information of the literature. We use the Microsoft Excel 2016 software to plot the publication trend line statistics. We then identify the core authors and institutions, using Price's Law [28], and partition journals using Bradford's Law [29].
- (2) Analysis of research topics. We extract high-frequency keywords according to the algorithm of the Ochiai coefficient, with the help of the Bicom 2.01 software, and construct the co-word matrix, similarity matrix, and dissimilarity matrix [30]. Then, we use the Ucinet 6 software to construct social network mapping, to analyze research hotspots.
- (3) Analysis of researcher fields. Based on the above statistical analysis, we use the SPSS 20 software to perform cluster analysis and multidimensional scale analysis. We define the main fields and key contents of the research, and classify the research hotspots and non-hotspots. On this basis, we put forward improvement directions for future research.



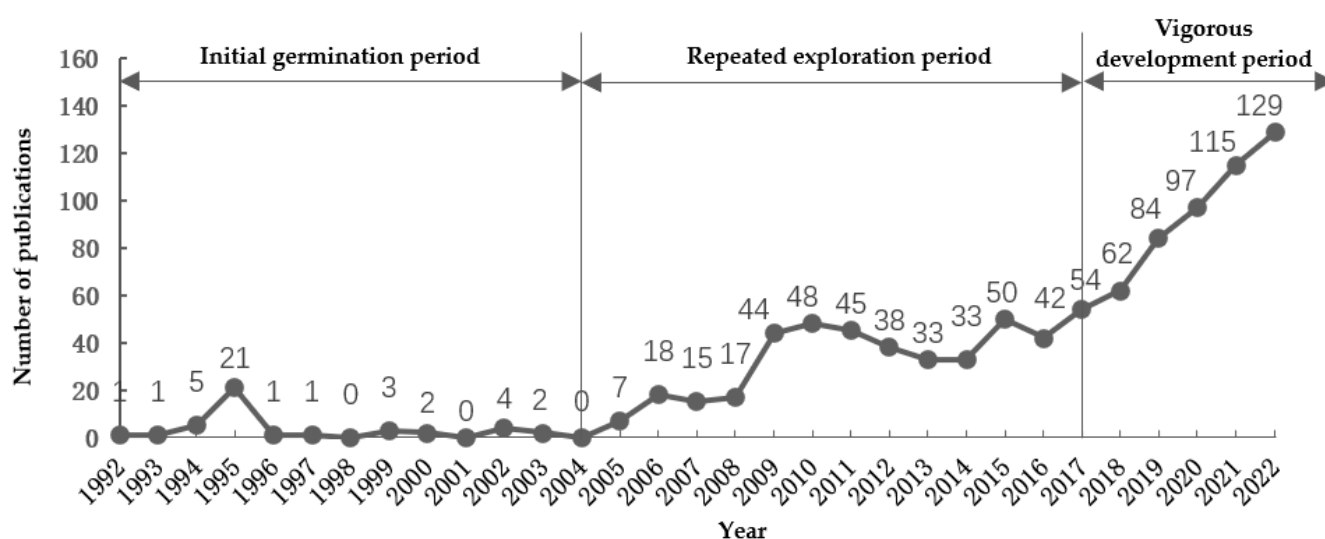
**Figure 1.** Technology roadmap.

## 4. Results and Analysis

### 4.1. Publication Trend Analysis

The number of publications is an important indicator to measure the progress and status of research in a field [31]. From the temporal changes in the number of publications in the rural living environment improvement field in China (Figure 2), we can see that the overall trend of the number of publications is growing and has prominent stage characteristics. It can be roughly divided into three periods:

- (1) Initial germination period (1992–2004). Forty-one articles were published during the thirteen years, accounting for 4.2% of the total. The average annual number of articles was about three, which was small, and the increase needed to be more significant. The peak was in 1995. The reason for this was that the National Patriotic Health Campaign Committee organized the first background survey on rural toilets and excreta disposal in China, in 1993. Subsequently, provinces released text-based survey reports in 1995, so the number of articles published in this year increased sharply.
- (2) Repeated exploration period (2005–2016). Three-hundred and ninety articles were published during this twelve year period, accounting for 40.1% of the total. The average annual number of articles reached 32, which was a significant increase. However, relevant research was still in the exploration stage, so the number of publications showed a fluctuating upward trend.
- (3) Vigorous development period (2017–2022). Five-hundred and forty-one articles were published in these six years, accounting for 55.7% of the total. The average annual number of reports was as high as 90, showing a significant increase. This indicates that the rural living environment improvement research was receiving more attention. The number of articles issued maintained the growth trend for extended periods.



**Figure 2.** Documented statistics of rural living environment publications volume, from 1992 to 2022.

#### 4.2. Authors and Institutions Analysis

The analysis of authors and institutions helps to understand the research strength in the rural living environment improvement. This paper measured the distribution of authors using Price's law, one of the classical laws of bibliometrics. The implication of this law is, "in the same field, half of the papers are written by a group of core authors whose number is roughly equal to the square root of the total number of authors". This law can be expressed as a mathematical formula:

$$M = 0.749\sqrt{N_{max}} \quad (1)$$

where  $M$  indicates the minimum number of papers published by the core authors in this field.  $N_{max}$  shows the number of papers published by the most productive authors [28]. These 972 papers had a total of 2127 authors and 863 first authors. Each paper had an average of 2.19 authors, indicating a high degree of cooperation. Among the research on improving the rural living environment, the most productive authors published nine papers. By calculation,  $M_p = 0.749 \times \sqrt{9} \cong 2.25$ . In other words, authors who published more than two papers can be regarded as core authors (Table 2). In the improvement of the rural living environment, there were 92 core authors, with 354 publications. The most productive authors, including Yanqiang Du, Bo Wang, and Fawen Yu, made outstanding contributions to the study of rural living environment improvement. Most of the core authors published their articles after 2015. At this time, the related research on rural living environment improvement, gradually entered the booming development period, and many excellent researchers emerged. Table 2 shows some of the core authors.

After sorting and ranking the number of published papers of all research institutions, it was found that the highest number of publications from a single research institution was 15 (Table 3). After calculation,  $M_p = 0.749 \times \sqrt{15} \cong 2.901$ . This means that institutions with more than two publications are core research institutions. Among the 614 research institutions, there are 40 core research institutions, with a total of 196 published papers. The core research institution that issued the most papers was the School of Public Administration of Nanjing Agricultural University, which focused on applying the Public Private Partnership (PPP) model, farmers' participation, and introducing social capital in rural environmental government. In addition, the College of Economics and Management of Northwest A&F University, the Institute of Rural Development of Chinese Academy of Social Sciences, the School of Economics and Management of Huazhong Agricultural University, and the College of Agriculture and Rural Development of the Renmin University of China also had a high degree of activity.

**Table 2.** Top ten core authors in the field of rural living environment improvement.

No.	Author	Institute	T.P.
1	Yanqiang Du	School of Public Administration, Nanjing Agricultural University	9
2	Bo Wang	Rural Center of Environmental Planning Institute, Ministry of Ecology and Environment	9
3	Fawen Yu	Institute of Rural Development, Chinese Academy of Social Sciences	9
4	Bin Fan	Research Center for Eco-Environment, Chinese Academy of Sciences	8
5	Changhua Ju	Nanjing Institute of Environmental Sciences, Ministry of Environmental Protection	7
6	Ning Li	School of Marxism, East China University of Science and Technology	7
7	Qinfang Sun	Nanjing Institute of Environmental Sciences, Ministry of Environmental Protection	7
8	Lin Zhu	Nanjing Institute of Environmental Sciences, Ministry of Environmental Protection	7
9	Fang Wang	School of Sociology and Public Administration, East China University of Science and Technology	6
10	Xiahui Wang	Environmental Planning Institute, Ministry of Ecology and Environment	6

Note: T.P. = total publications.

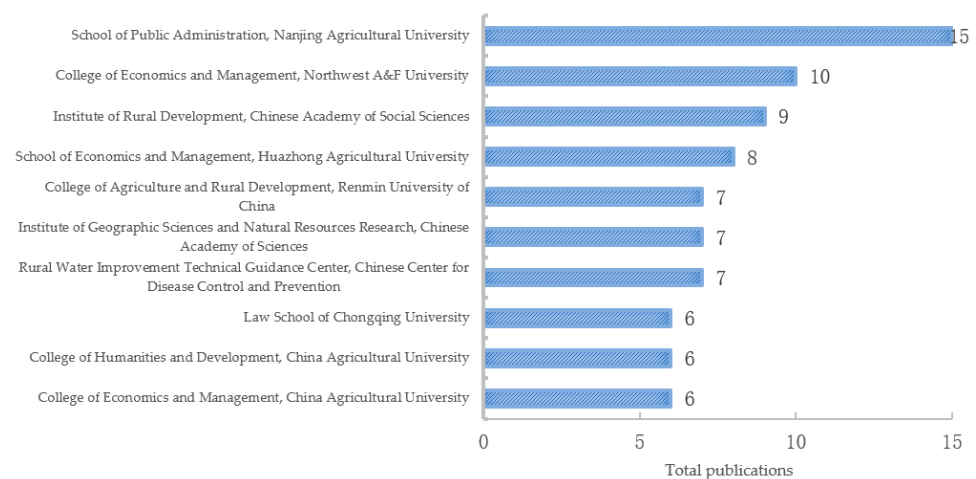
**Table 3.** Discrete status table of sample literature.

Division	T.J.	%	T.P.	%	Range	T.P./T.J.
Core area	9	3.11	297	30.56	(18,77)	33.00
Related area	50	17.31	334	34.36	(4,17)	6.68
Marginal area	230	79.58	341	35.08	(1,3)	1.48
Total	289	100.00	972	100.00	(1,77)	3.36

Notes: T.J. = total journals; T.P. = total publications; Range = the range of the number of journals within different divisions; T.P./T.J. = average loading density.

From Table 2 and Figure 3, it can be found that:

- (1) The number of papers published by core authors accounted for 36.42% of the total, and the number of papers published by core research institutions accounted for 20.16% of the total. The proportion has stayed within 50% and needs to be further improved.
- (2) The core authors and institutions are distributed in east China, south China, central China, north China, northeast China, southwest China, and northwest China. The geographical distribution is wide, indicating that rural living environment improvement is a hot research topic nationwide.
- (3) The research force is mainly significant universities and research centers in China. Social parties are less involved in the research. In the future, with the continuous implementation of rural revitalization strategies and the gradual realization of environmental remediation goals, this field needs more attention and input from multiple research subjects.

**Figure 3.** Top ten core research institutions with published papers.

#### 4.3. Source Journals Analysis

Based on the data in this paper, 289 high-quality journals have published literature related to rural living environment improvement. The highest number of publications in one journal, is 77. The dispersion of the journal literature can be revealed by Bradford's law. This law can identify journals in the core, related, and marginal areas, by ranking all journals in a given discipline in descending order of the number of publications [29]. The total number of publications in the three regions is approximately equal. The number of journals corresponds to the following proportional relationship:

$$x_1 : x_2 : x_3 = 1 : n : n^2 \quad (2)$$

where  $x_1$ ,  $x_2$ , and  $x_3$  indicate the total number of journals in different regions.  $n$  indicates the Bradford coefficient, which can be calculated as follows:

$$n = \sqrt[x]{(e^E \times Y)}, \quad (3)$$

where  $x$  indicates the number of partitions, which is equal to three.  $E$  means the Euler coefficient, which is equal to 0.5772.  $Y$  indicates the highest number of journal publications. By calculation,  $n = \sqrt[3]{(2.718^{0.5772} \times 77)} \approx 5$ . Thus, the ratio of the number of journals in the three partitions is approximately 1:5:25.

Among them, the number of journals in the core area can be calculated by the following formula:

$$P = 2Ln(e^E \times Y), \quad (4)$$

where  $P$  indicates the number of journals in the core area. By calculation,  $P = 2Ln(2.718^{0.5772} \times 77) \approx 9$ . We can further calculate the number of journals, publications, proportion, and average density of articles in the relevant and marginal regions [32,33]. Then, we can obtain the discrete status of literature related to improving the rural living environment (Table 3).

The core area contains significantly higher article density than the related and marginal areas. This indicates that the core effect of the research related to rural living environment improvement is more substantial. However, on the other hand, there is also a variable volume of publications. Table 4 summarizes the top three journals in the three areas, regarding the number of publications. We can see that the publication of journals in different areas, differ significantly. The research results are more scattered, and the journal categories are more complicated, but in general, agricultural, management, and economic journals are the main ones.

**Table 4.** Statistics of the top three journals in the three regions.

Division	Journal	T.P.	I.F.
Core area	<i>Agricultural Economy</i>	77	1.737
Core area	<i>Environmental Protection</i>	54	2.352
Core area	<i>Ecological Economy</i>	31	2.453
Relevance area	<i>Water &amp; Wastewater Engineering</i>	16	1.093
Relevance area	<i>Journal of Arid Land Resources and Environment</i>	15	3.187
Relevance area	<i>Journal of Nanjing Tech University (Social Science Edition)</i>	14	2.750
Marginal area	<i>City Planning Review</i>	3	3.227
Marginal area	<i>Contemporary Economic Management</i>	3	3.884
Marginal area	<i>Progress in Geography</i>	3	6.046

Notes: T.P. = total publications; I.F. = impact factor.

#### 4.4. High-Frequency Keywords Analysis

##### 4.4.1. High-Frequency Keywords Extraction

Keywords represent a distillation of the article topics. Analyzing high-frequency keywords helps to detect the research hotspots in the field and reveal the development pulse and direction of academic research [34]. This paper extracted 1880 keywords in the sample literature, using the Bicom software. The following formula can identify the high-frequency keywords:

$$I = \frac{1}{2} \left( -1 + \sqrt{1 + 8I_1} \right) \quad (5)$$

where  $I$  indicates the minimum number of occurrences of high-frequency keywords, and  $I_1$  means the number of keywords with a frequency of one [35]. According to the statistics, the total number of keywords appearing only once was 1490. By calculation,  $I_n \cong 54.09$ . Therefore, high-frequency keywords should appear more than 54 times. Accordingly, the only high-frequency keywords, are “rural”, “rural revitalization”, “rural environment”, “rural environmental governance”, “rural living environment”, and “environmental governance”. This number is too small to conduct subsequent analysis. Therefore, this paper defines those with a frequency greater than or equal to seven as high-frequency keywords. Finally, we obtained 63 high-frequency keywords, as shown in Table 5.

**Table 5.** High-frequency keywords of the sample literature.

No.	Keywords	Frequency	No.	Keywords	Frequency
1	rural	83	33	pollution control	11
2	rural revitalization	69	34	rural household garbage	11
3	rural environment	60	35	rural domestic sewage treatment	11
4	rural environmental governance	60	36	influencing factor	11
5	rural living environment	55	37	rural garbage treatment	10
6	environmental governance	55	38	garbage treatment	10
7	living environment	54	39	rural sewage	10
8	domestic sewage	42	40	Jiangsu province	10
9	governance	34	41	rural governance	10
10	rural ecological environment	31	42	sewage treatment	10
11	new rural construction	27	43	pay willingness	9
12	rural living environment improvement	23	44	public participation	9
13	rural toilet renovation	22	45	agricultural non-point source pollution	9
14	ecological environment	22	46	non-point source pollution	9
15	countermeasure	21	47	rural revitalization strategy	9
16	new rural	20	48	environmental protection	9
17	ecological civilization	20	49	rural water environment	9
18	toilet renovation	19	50	comprehensive regulation	8
19	disposal of feces	17	51	problem	8
20	environment pollution	16	52	ecological governance	8
21	social capital	16	53	cooperative governance	8
22	treatment strategy	15	54	rural sewage treatment	8
23	rural environmental pollution	15	55	green development	8
24	rural toilet	15	56	countermeasures and suggestions	8
25	sanitary toilet	14	57	rural environmental protection	8
26	beautiful countryside	14	58	farmer	7
27	rural environmental improvement	12	59	sustainable development	7
28	constructed wetland	12	60	pluralistic governance	7
29	governance model	12	61	rural area	7
30	current situation	12	62	household garbage	7
31	domestic sewage	12	63	rural environment comprehensive improvement	7
32	collaborative governance	11			

#### 4.4.2. Matrix Construction

Matrix construction is an essential prerequisite and foundation for mapping knowledge and conducting social network analysis, cluster analysis, and multidimensional scale analysis. First, this paper used the Bicom software to count the frequency of two high-frequency keywords appearing together, to generate a  $63 \times 63$  co-word matrix (Table 6).

**Table 6.** Co-word matrix of high-frequency keywords of the sample literature (part).

	Rural	Rural Revitalization	Rural Environment	Rural Environmental Governance	Rural Living Environment	Environmental Governance
Rural	83	4	0	0	7	13
Rural revitalization	4	69	7	4	9	8
Rural environment	0	7	60	2	1	3
Rural environmental governance	0	4	2	60	0	0
Rural living environment	0	9	1	0	55	2
Environmental governance	7	8	3	0	2	55

Secondly, we transformed the co-word matrix into a similarity matrix, with the help of the Ochiai coefficient, which is used to determine the degree of correlation between two keywords. The calculation formula is as follows:

$$O = \frac{F}{\sqrt{C_1} \times \sqrt{C_2}} \quad (6)$$

where  $O$  indicates the Ochiai coefficient,  $F$  shows the number of co-occurrences of keywords A and B,  $C_1$  indicates the word frequency of A, and  $C_2$  indicates the word frequency of B [30].

Finally, the similarity matrix is transformed into a different matrix using the formula “ $1 - \text{Similar matrix} = \text{Different matrix}$ ”. In this way, we can avoid too many 0 values in the similarity matrix affecting the analysis results, and meet the demand of multivariate statistics (Table 7).

**Table 7.** Dissimilarity matrix of high-frequency keywords of the sample literature (part).

	Rural	Rural Revitalization	Rural Environment	Rural Environmental Governance	Rural Living Environment	Environmental Governance
Rural	0.000	0.947	1.000	1.000	1.000	0.896
Rural revitalization	0.947	0.000	0.891	0.938	0.854	0.870
Rural environment	1.000	0.891	0.000	0.967	0.983	0.948
Rural environmental governance	1.000	0.938	0.967	0.000	1.000	1.000
Rural living environment	1.000	0.854	0.983	1.000	0.000	0.964
Environmental governance	0.896	0.870	0.948	1.000	0.964	0.000

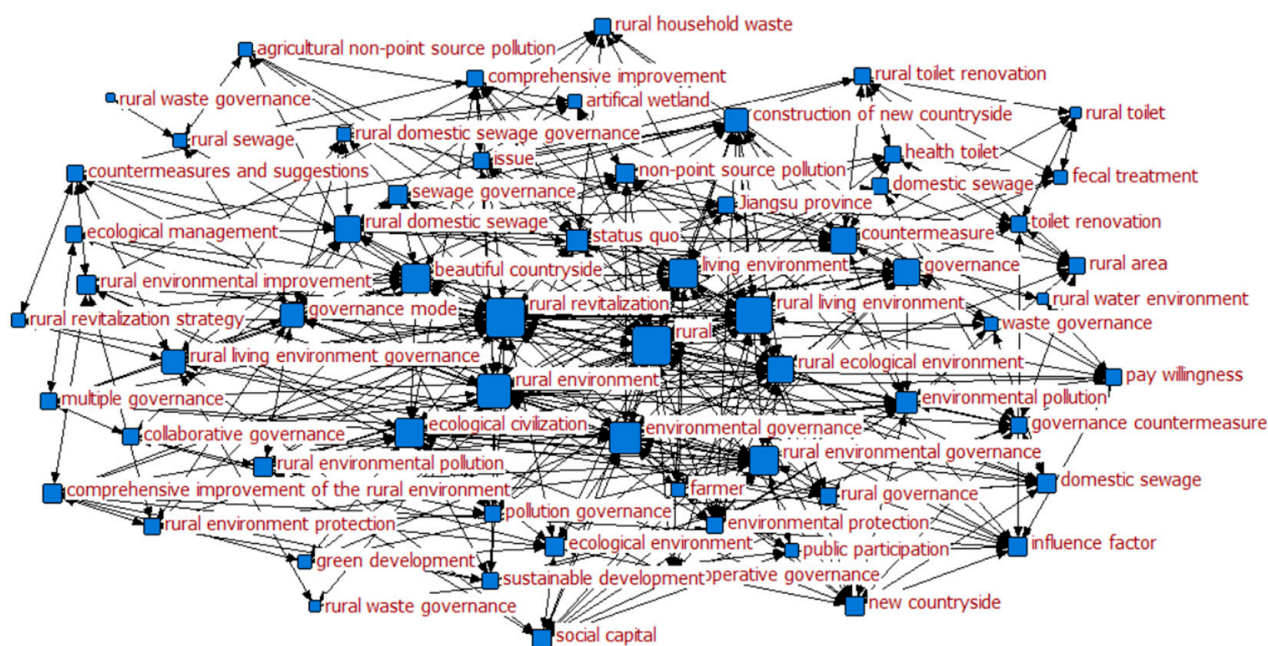
The values in the different matrices are greater than or equal to 0 and less than or equal to 1. Closer to 0 indicates a higher degree of correlation between keywords, and closer to 1 indicates a lower degree of correlation between keywords [36]. Table 7 shows that the high-frequency keywords in the literature related to improving the rural living environment, have a low degree of similarity and are more distantly related.

#### 4.5. Social Network Analysis

In a social network, the nodes represent each individual, and the lines between nodes represent individual relationships. Through the nodes and lines, a structural network of social relations in the field is formed [37]. Using this, we can understand the relationship between individuals, and between individuals and society, better. In this paper, we use the Ucinet software to draw a social network map, measure the centrality of high-frequency keywords, and conduct research hotspot analysis.

#### 4.5.1. Keyword Social Network Analysis

In the social network, the larger the node, the more co-occurrence of the keyword with other keywords. The thicker the connecting line, the higher the correlation between the keywords [38]. A high-frequency keyword social network map was generated using Ucinet (Figure 4). It can be seen that the research related to rural living environment improvement shows a dense social network knot, from point and line to surface. The absence of isolated nodes, indicates that the links between the various sub-topics are relatively strong. From the inner region to the outer regions, they can be roughly divided into the research's core, middle, and edge layers [39].



**Figure 4.** Social network mapping of high-frequency keywords in the sample literature.

Among them, “rural” is located at the center of the network, reflecting that the study’s main target is the vast rural areas of China. Around “rural”, the keywords at the core level are “rural living environment”, “rural revitalization”, “rural ecological environment”, “ecological civilization”, “environmental governance”, “rural environment”, and so on. It can be seen that the relevant research attaches great importance to the improvement and enhancement of the quality of the rural living environment. On the one hand, this is due to the poor ecological environment in rural areas, which determines the urgent need for environmental improvement. On the other hand, it is mainly due to the support and policy guarantees of the government.

The keywords in the middle level are “governance”, “beautiful countryside”, “current situation”, “living environment”, “rural living environment improvement”, “new rural construction”, “rural environmental management”, “environmental pollution”, “governance mode”, “countermeasures”, and so on. These mainly involve the rural living environment improvement’s purpose, and the realization of path improvement. However, this region is less hot than the core layer and needs further development.

The keywords located in the edge layer are “sanitary toilets”, “manure treatment”, “sewage treatment”, “collaborative treatment”, “rural water environment”, “artificial wetland”, “rural sewage”, and so on. The issues in focus are the detailed aspects or specific measures of rural living environment improvement. It has a low centrality, which indicates that the number of existing relevant studies is small, and the degree of attention needs to be increased.

#### 4.5.2. Measurement of Node Centrality

Centrality analysis is a common social network analysis method, which measures each node's role in the network. The measures include degree centrality, betweenness centrality, and closeness centrality. They were calculated using the keyword co-occurrence matrix in the Ucinet software (Table 8) [40,41].

(1). Degree centrality: this reflects the connection and communication ability of nodes in the social network. In a social network, when two nodes appear together once, a connection is made. The more connections between nodes, the higher the degree centrality of the keyword it represents. The calculation method of degree centrality is:

$$Degree_i = \sum_{j=1}^N w_{ji} \quad (7)$$

where  $w_{ji}$  indicates the number of links between node  $j$  and node  $i$ , that is, the number of co-occurrences of keywords represented by the two nodes.

(2). Betweenness centrality: this reflects nodes' coordination and control ability in a social network. When a node is on the shortest path connecting other nodes, it can control the access and flow of information between them. In this case, the keyword represented by the node has a higher betweenness centrality. The calculation method of betweenness centrality is:

$$Betweenness_i = \sum_j^n \sum_k^n b_{jk} \quad (8)$$

where  $b_{jk}$  indicates whether node  $i$  is on the shortest path connecting node  $j$  and  $k$ . If,  $b_{jk} = 1$ ; conversely,  $b_{jk} = 0$ .

(3). Closeness centrality: this reflects the degree of freedom of nodes in the social network. If a node is close to other nodes, it can directly connect to other nodes. Then, it has high independence in information transmission and is not easily controlled by other nodes. However, this also means that the node does not occupy the core position of the social network. The calculation method of closeness centrality is:

$$Closeness_i = \frac{1}{\sum_{j=1}^n d_{ij}} \quad (9)$$

where  $d_{ij}$  shows the shortest path length connecting node  $i$  and node  $j$ .

As can be seen from Table 8, keywords with higher degree centrality and betweenness centrality, are roughly consistent with keywords with lower closeness centrality. These mainly include rural, rural revitalization, environmental management, rural environment, living environment, rural living environment, and so on. They are consistent with the keywords in the core layer of the social network map. It can be concluded that the above keywords occupy the core position of the social network of rural living environment improvement. They are the hot topics in this field, play an essential mediating role, and have a high control power in the social network. In addition, the core position of the above keywords determines that they are more likely to be controlled and influenced by other keywords, and more likely to cross-fertilize with different keywords in the study.

**Table 8.** Statistical table of the top ten keywords of degree centrality, betweenness centrality, and closeness centrality.

No.	Keywords	D.C.	No.	Keywords	B.C.	No.	Keywords	C.C.
1	rural	98	1	rural	240.031	2	rural revitalization	97
2	rural revitalization	85	2	rural revitalization	158.905	1	rural	99
6	environmental governance	54	3	rural environment	131.408	5	rural living environment	99
3	rural environment	50	5	rural living environment	131.237	3	rural environment	102
9	governance	49	6	environmental governance	102.413	6	environmental governance	103
7	living environment	46	26	beautiful countryside	98.81	7	living environment	106
5	rural living environment	43	15	countermeasure	98.52	26	beautiful countryside	108
4	rural environmental governance	37	8	rural domestic sewage	96.176	9	governance	109
15	countermeasure	35	4	rural environmental governance	73.621	17	ecological civilization	110
10	rural ecological environment	34	7	living environment	71.413	29	governance model	111

Notes: D.C. = degree centrality; B.C. = betweenness centrality; C.C. = closeness centrality.

## 5. Discussion

Based on the above results, we have a preliminary understanding of the external characteristics of the sample literature. Improving the rural living environment is an important part of realizing rural revitalization. The Chinese government, and people from all walks of life, have been working towards this goal. However, as of now, China's rural environmental problems have not yet been fully addressed. We have a long way to go to study it. Therefore, it is necessary to dig deeper into the research content of rural living environment improvement and explore research hotspots and development directions.

### 5.1. Research Field and Key Content

To achieve this goal, we adopt the method of cluster analysis. According to the degree of proximity between the data, they are quantitatively classified, to determine the main topics in the field of rural living environment improvement in China. A word-part matrix was generated using Bicom and imported into SPSS. A clustering dendrogram of high-frequency keywords was obtained (Figure 5). Based on the clustering results, the rural living environment improvement research can be broadly classified into six fields.

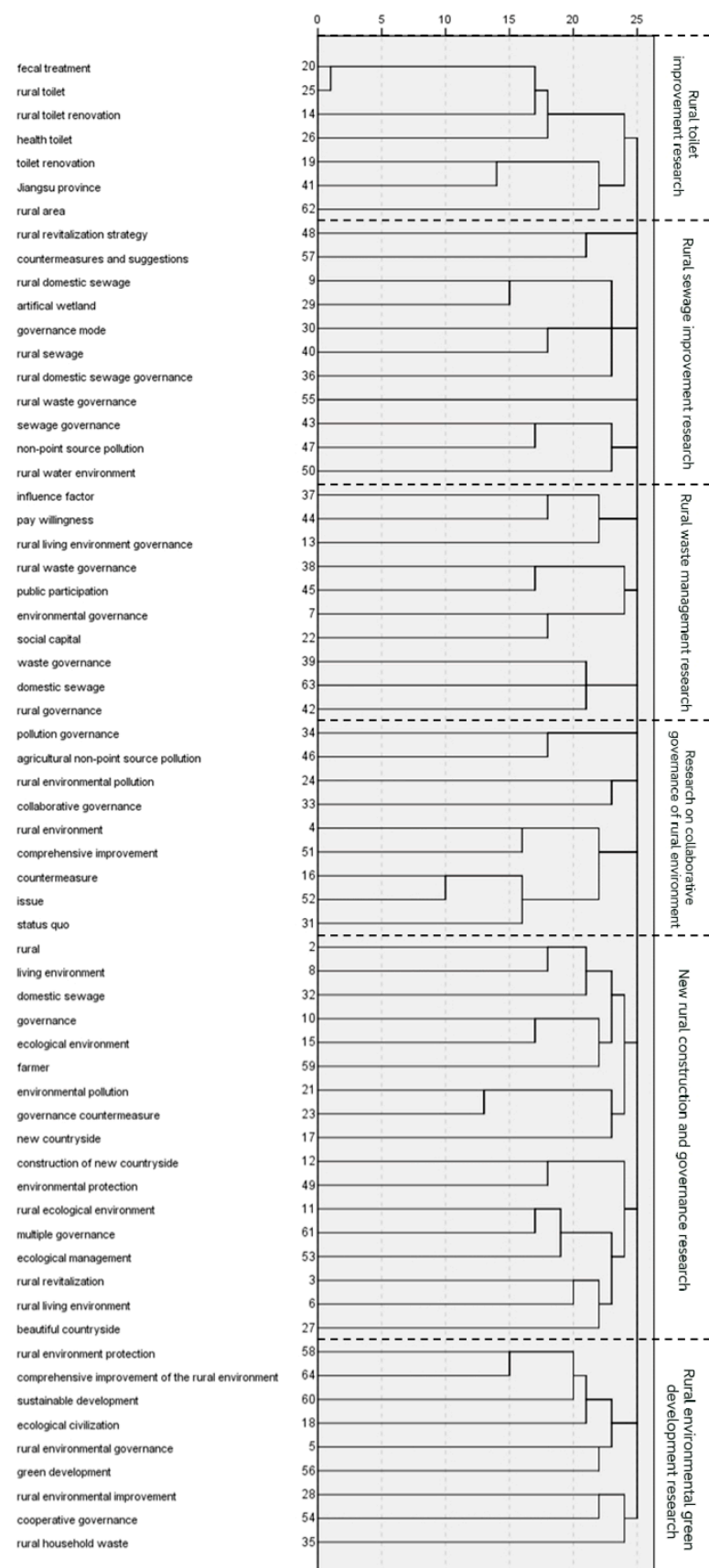


Figure 5. Clustering tree diagram of high-frequency keywords in the sample literature.

- (1) Field 1: Rural toilet improvement research. This includes seven keywords: fecal treatment, rural toilet, rural toilet renovation, health toilet, toilet renovation, Jiangsu province, and rural area. Rural toilet improvement is essentially a toilet revolution [42], benefiting people concerned with rural revitalization. China has implemented several top-down toilet improvement campaigns at different times and has achieved prominent stage achievements. Among them, toilet improvement in Jiangsu Province is highly typical. From point to point, before 2005, to full-scale after 2005, the prevalence of sanitary toilets in rural areas of the province has increased significantly, and the “three-format” biogas toilets, with local characteristics, have been developed. Most of the existing studies by Chinese scholars on rural toilet improvement, start from a survey of the current situation, using a random sampling method to select a certain number of rural areas in a particular region as the survey object. The surveys have focused on the type of latrine construction, the prevalence and management of sanitary latrines, the harmless treatment rate of dung, the investment and use of funds, and the maintenance and management of restrooms in the area [43]. The results showed that, (i) there are three main types of rural sanitary toilets: three-compartment septic tank type, flush type (complete sewerage system), and flush type (small centralized sewage treatment system). Among these, the three-compartment septic tank type is most researched [44]. (ii) At present, the penetration rate of rural sanitary toilets, the rate of harmless treatment of manure, the efficiency of capital use, and the efficiency of management and maintenance are all at a low level, and there are large site and regional differences. These are influenced by villagers’ literacy, ethnicity, number of permanent household residents, drinking water habits, and hand-washing habits [45]. (iii) Rural latrine conversion faces an imperfect policy system, weak awareness of villagers in latrine construction, insufficient motivation for technological innovation, and lack of industry norms. To guarantee the smooth implementation of latrine conversion, measures such as increasing financial investment, strengthening publicity and education, and improving supervision, can be taken [46].
- (2) Field 2: Rural sewage improvement research. This involves 11 keywords: rural revitalization strategy, countermeasures and suggestions, rural domestic sewage, artificial wetland, governance mode, rural sewage, rural domestic sewage governance, rural waste governance, sewage governance, non-point source pollution, and rural water environment. Focusing on the critical issue of rural wastewater, Chinese scholars have mainly explored it from two perspectives. (i) The technical level of rural sewage treatment. The treatment techniques of rural sewage can be divided into two categories. One is a single processing technique. It includes constructed wetland, biological contact oxidation, MBR integration, high-load subsurface infiltration composite technology, soil-based high-load microbial filter bed technology, ecological integrated system pool, etc. The other, is combined processing technology. It includes anaerobic–anaerobic treatment, anaerobic–aerobic treatment, anaerobic–ecological treatment, and others [47,48]. The main modes of rural sewage treatment include the urban-rural unified treatment mode, village centralized treatment mode, and decentralized treatment mode for farmers. The specific application needs to be tailored to local conditions. (ii) Management level of rural sewage management. In reality, the management of rural sewage is not smooth. Weak integration, unreasonable technical models, operation and maintenance sustainability, insufficient public participation, and other problems persist. In this regard, the following must be done. Firstly, we must improve coordination and establish efficient operational management systems. Secondly, we need to emphasize the main role of villagers and improve the ability of rural sewage collaborative treatment. Finally, we should learn from the advanced sewage treatment experiences of developed countries, to realize intelligent and digital treatment [49,50].

- (3) Field 3: Rural waste management research. This includes ten keywords: influence factor, pay willingness, rural living environment governance, rural waste governance, public participation, environmental governance, social capital, waste governance, domestic sewage, and rural governance. Rural waste management is an essential part of living environment improvement. To better achieve “the level of harmless treatment of rural household garbage is significantly improved”, we need to be good at identifying problems and summarizing experiences. (i) The current issues of rural waste management should be clarified. Scholars have pointed out that waste management in rural areas has shortcomings in preliminary planning, legal protection, operation and maintenance costs, terminal technology, source separation, farmers’ participation, and institutional construction. The waste management capacity needs to be improved urgently, and the system needs to be perfected [51]. (ii) It should be clear that the key to rural waste management lies in people. Scholars have conducted empirical studies with the help of models or methods, such as the evolutionary game model, Matlab simulation, double-hurdle model (DHM), binary logistic model, ordered probit model, and conditional value method (CVM). It was identified that public participation and pay willingness in rural waste management is mainly influenced by farmers’ education level, sense of environmental responsibility, income level, the credibility of village officials, social capital, the proportion of households working outside, perception of environmental risks, and policy awareness [52]. (iii) To promote the shift of rural waste management from fragmentation to pluralistic co-management, it is necessary to address many existing problems from multiple aspects, such as government, village committees, villagers, and society [53]. Specific measures include, increasing policy support and developing the rural economy; innovating the governance model and exploring the establishment of a farmer payment system for waste management; improving the operational capacity of village cadres and innovating the communication and exchange mechanism between cadres and the community; attaching importance to endogenous motivation and promoting public participation; and rebuilding social capital and playing the complementary role of social organizations [54].
- (4) Field 4: Research on collaborative governance of the rural environment. This includes nine keywords: pollution governance, agricultural non-point source pollution, rural environmental pollution, collaborative governance, rural environment, comprehensive improvement, countermeasure, issue, and status quo. Collaborative governance is a new idea and direction of rural environmental governance. In the report of the 19th National Congress of the Communist Party of China, it was pointed out that we should, “build a social governance pattern of common construction and shared governance”. Currently, the main reason for many problems in the rural ecological environment is the need for more responsibility from the government, enterprises, farmers, NGOs, and other relevant bodies. This has led to the fragmentation of collaborative governance functions, disorderly ways, and single subjects. To fully implement the strategy of rural revitalization and promote the thorough improvement of the rural living environment, it is necessary to realize the multi-governance and collaborative governance of stakeholders, and give full play to the unique advantages of different responsible subjects. (i) It is necessary to strengthen supervision, to improve the government’s governance capacity. The government is an essential leader in the collaborative governance of the rural environment, which influences the formulation of policies, the participation of subjects, the investment of human and material resources, and the supervision of power in the collaborative governance process [55]. (ii) Incentives should be emphasized, to enhance the motivation of enterprises and social organizations. Enterprises and social organizations guarantee cooperative environmental governance in rural areas. The combination of material and spiritual incentives can be adapted, to actively promote enterprises and social organizations to participate in rural environmental collaborative governance. (iii) To ensure villagers play the leading role. Villagers are essential subjects of collaborative

environmental governance in rural areas. Strengthen the publicity and education of environmental management, so that the people understand the concept of “ecological benefits are economic benefits”. Play the role of the main body to promote collaborative governance.

- (5) Field 5: New rural construction and governance research. This includes 17 keywords: rural, living environment, domestic sewage, governance, ecological environment, farmer, environmental pollution, governance countermeasure, new countryside, construction of new countryside, environmental protection, rural ecological environment, multiple control, ecological management, rural revitalization, rural living environment, and beautiful countryside. The construction of the new socialist country first started in 2005. It has been moving toward, “productive development, affluent living, civilized countryside, neat and clean village, and democratic management”. In recent years, this has been progressing hand in hand with rural revitalization and rural living environment improvement. The amount of literature on the theme of new rural construction and governance could be more significant. The research themes mainly focus on the problem analysis and path reflection of new rural construction and management. The problem sources of ecological control of new rural areas in China, can be divided into natural and artificial. Biological factors include rural water pollution, vegetation destruction, waste pollution, soil pollution, air pollution, etc. Artificial factors include the need for more scientific village planning and villagers’ primary motivation, backward rural facilities, lack of funds and a single source, lack of a policy system, etc. In response to the above problems, reasonable optimization measures should start from scientific planning and management, increasing investment, improving infrastructure, strengthening environmental protection publicity, adjusting the industrial structure, and promoting supervision and control.
- (6) Field 6: Rural environment green development research. This includes nine keywords: rural environmental protection, comprehensive improvement of the rural environment, sustainable development, ecological civilization, rural environmental governance, green development, rural environmental improvement, cooperative governance, and rural household waste. The research on green development in rural environments can be divided into three segments. (i) Content and direction of green development of rural environment. Green development is a development pathway aimed at efficiency, harmony, and sustainability. With the ecological environment as the inner driving force of development, the essence is to deal with the relationship between the environment and development, and the interaction between urban and rural elements. The main direction of green development in rural areas, is to improve policy protection, strengthen infrastructure construction, innovate agricultural development methods, develop particular rural industries, accelerate environmental pollution control, etc. [56,57]. (ii) Benefit evaluation of green development of the rural environment. Scholars used the fuzzy comprehensive evaluation and hierarchical analysis methods to establish the index system. The degree of influence of four significant benefits of comprehensive agricultural development in Xinjiang province, China, was measured. The overall development trend of agriculture was judged, and relevant suggestions were made for the green development of agriculture [58]. (iii) Rural revitalization and green development. Many studies have shown that the green development of the rural environment has an apparent positive effect on the implementation of rural revitalization. Rectifying the rural living environment and realizing green development, are essential links and breakthroughs in implementing a rural revitalization strategy. This reveals that we should pay attention to the improvement and renovation of the rural environment. Form a linkage mechanism with the government, townships, and villagers, to jointly promote the green and sustainable development of the whole area.

Combining Figures 5 and 6, we can find that:

- (1) The keywords of field 1 are located in quadrant IV. This indicates that rural toilet improvement is not a research focus of rural living environment improvement and has yet to attract sufficient attention from domestic scholars. There are few research projects and little related literature.
- (2) The keywords of field 2 are partly located in quadrant III and partly in quadrant IV. This indicates that there has been a lot of research on rural sewage improvement in rural living environment improvement. Still, it has yet to develop into a research focus in this field.
- (3) The keywords of field 3 are located in quadrant I. This shows that rural waste management is a hot spot and the focus of research in rural living environment improvement. This issue has attracted significant attention from government at all levels and from domestic scholars. This is due to both the critical content of the research in this field and the essential work of rural living environment improvement.
- (4) The keywords of field 4 are located in quadrant II. This means that collaborative rural environmental management has specific research potential and is expected to develop into a new research focus.
- (5) Most of the keywords in field 5 and field 6 are located in quadrant III. This indicates that the attention and intrinsic motivation of the research related to new rural construction and green development, need to be increased.

Overall, there are only a small number of keywords in quadrant I. This shows that there are still a lot of marginal topics in the research field. However, that does not mean that there is not a need for research on these marginal topics. The improvement of the rural living environment is a broad and interlinked subject. Each link is indispensable. Scholars can properly conduct more research on non-hot topics. The accumulation of theory drives the progress of practice, and promotes the high-quality development of China's rural living environment improvement.

## 6. Conclusions

The improvement of the quality of the rural living environment has always been a key task of the Chinese government's rural work. The theories, tools, methods, and technologies of studying rural living environment improvement are constantly updated. It is particularly necessary to review the studies on it systematically.

Based on the bibliometrics method, this paper makes a scientific econometric analysis of 972 publications in the CNKI, on improving the rural living environment, focusing on the research progress and hot topics in this field. The results show that the number of publications has obvious stage characteristics. The core authors and institutions have a wide geographical distribution and low volume of publications. The source journals have a high dispersion. The social network can be divided into core, intermediate, and edge layers, based on the research heat. The main research includes six aspects: rural sewage improvement, rural waste management, rural environment collaborative treatment, rural toilet improvement, new rural construction and management, and rural environmental green development. The research of the last three needs to be deepened.

This work provides a comprehensive picture of the study of rural living environment remediation in China and fills in the blanks in this field. However, this paper inevitably has some shortcomings. Firstly, the depth and comprehensiveness of the study are not enough, because the samples are only from domestic databases. Besides, it is difficult to avoid the influence of the authors' subjectivity in the research analysis. The next step we need to take, is to overcome the weaknesses and carry out a more in-depth and comprehensive analysis.

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