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Review

Progress and Prospects of Non-Grain Production of Cultivated Land in China

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Abstract: Cultivated land is essential for grain production. As a major agricultural country, China's non-grain use of cultivated land not only affects national food security and sustainable agricultural development but also impacts the quality of cultivated land and farmers' livelihoods. This study used bibliometrics to visualize and analyze 413 articles from the China Knowledge Network (CNKI) and Web of Science (WOS) databases concerning non-grain production of cultivated land (NGPCL). The results reveal the following: (1) The number of annual publications in this area has increased from 2009 to 2023 with the focus of NGPCL research shifting from describing the phenomenon to analyzing its driving mechanisms and then to exploring spatial patterns and governance. (2) The spatial distribution of research institutions is marked by the convergence of multiple entities with the central and eastern regions of China being pivotal research areas and transnational collaborative research becoming increasingly visible. (3) High-frequency keywords include NGPCL, food security, and farmland transfer, focusing on the historical context, effects, driving mechanisms and preventative strategies related to NGPCL. There is a notable evolutionary relationship between farmland transfer and NGPCL themes. (4) Future research should broaden the geographical scope and assess NGPCL trends from global, regional, and multiscale perspectives. Efforts should be made to enhance data accuracy and conduct spatial and temporal simulations, trend analyses, and risk assessments. Furthermore, policy design should consider the structure of human–land relationships to support sustainable agricultural development. This study provides an important reference for deepening and broadening the field of NGPCL.

Keywords: non-grain production of cultivated land; bibliometric method; CiteSpace software; China

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1. Introduction

Cultivated land is essential for grain production, serving as a vital strategic resource worldwide and the foundation for human reproduction, survival, and development [1]. It is also critical for ensuring national prosperity, stability, food security, and ecological balance [2,3]. The process of global urbanization and industrialization has led to notable changes in industrial structures, population distributions (both urban and rural), and patterns of cultivated land utilization [4,5]. Consequently, several pressing issues have emerged, such as "non-agricultural" activities [6], ecological degradation [7], and farmland abandonment [8]. These global concerns are especially significant for China, which is a populous country with 1.4 billion people that heavily relies on food production to ensure national security [9]. In recent years, various factors, including the rising cost of agricultural inputs, low profitability of grain cultivation for farmers, and improvements in the dietary structure of urban and rural residents, have led to an increasing phenomenon known as non-grain production on cultivated land (NGPCL) in China [10–12]. According to recent studies, as of 2020, the non-grain planting area in China included 50.719 million hectares,

accounting for approximately 30.28% of the country's cultivated land, and this area is continuing to expand [13]. This poses a substantial threat to China's food security and sustainable development [3].

International research concerning NGPCL has focused on crop diversification [14]. It primarily focuses on the negative ecological and social problems caused by climate change, such as landscape fragmentation, soil degradation, and changes in farmers' livelihoods [15,16]. However, Chinese scholars have varying interpretations of the NGPCL, dividing it into a narrow and broader sense. In the narrow sense, it refers to the cultivation of cash crops such as vegetables, fruits, and flowers on cultivated land [17]. In a broader sense, it includes all non-grain crops grown on cultivated land [11], including those used for breeding, forestry, the fruit industry, farmland abandonment, leisure tourism, and grain crops grown for fuel ethanol production [18–20]. Scholars have categorized NGPCL into different types based on various perspectives. Based on the degree of utilization of cultivated land, NGPCL can be divided into abandoned farmland NGPCL and overplanted NGPCL [21]. Depending on the type of output, NGPCL is used for growing non-grain products, NGPCL is used for growing non-edible agricultural products, and NGPCL is used for growing non-agricultural products [22,23]. Moreover, its classification is based on the degree of damage to the plow layer with weak damage involving the planting of herbaceous plants, fruit trees, tea trees, and other low shrubs; gradual damage involving economic forests, fruits, fast-growing forests, and horticultural transplanting with soils; and severe damage involving pond digging for aquaculture and hardened covering [24–35]. NGPCL is a new issue that has emerged in the context of China's unique circumstances, reflecting the complexity of the country's agricultural restructuring and economic development.

To accurately assess the scale of NGPCL, scholars have employed the NGPCL rate, which is based on household survey data [26,27], statistical yearbook data, or remote sensing interpretation data [28–31]. This rate measures the proportion of non-grain sown area to the total area of cultivated land or the proportion of non-grain crops to the total sown area of crops [32,33]. In some cases, researchers also use the proportion of income spent on food or food expenditures as a share of total income [34]. Additionally, scholars have utilized various methods to investigate the driving factors of NGPCL, including the logistic regression model [35], spatial Durbin model [3], multiple regression model [28,36], geographical detector model [37], spatial econometric model [29], spatial autocorrelation analysis [38], and Tobit model [26]. These research methods and findings have provided valuable insights for understanding and studying the issue of NGPCL. However, there is still a lack of systematic sorting and research in this field. Most existing review studies summarize the current status, scale, content, and methodology of research on NGPCL in China through literature reviews [23,25,39], while some individual scholars have visualized the research progress of China's NGPCL using bibliometric methods [40]. However, these review articles only analyzed the China Knowledge Network (CNKI) database and did not consider articles published by Chinese scholars on the Web of Science. As a result, they fail to provide a comprehensive interpretation of the current situation of research on NGPCL in China. Moreover, current bibliometric methods are limited in their ability to display the number of articles, authors, institutions, research hotspots, and topic evolution. They do not offer a visual representation of the distribution of the target field in terms of research scales or hotspot areas. Therefore, in this study, we employed CiteSpace 6.2.R6 software and inductive statistics to conduct a comprehensive analysis of 413 articles on NGPCL from the CNKI and Web of Science (WOS) databases. Our study aimed to address the following questions:

(1) What are the temporal trends and evolutionary relationships in the number of publications in this field?
(2) What is the spatial distribution and correlation of high-yield authors, high-yield research organizations, research scales, and hotspot areas in this field?
(3) What are the research hotspots and themes in this field? How have they developed and evolved? What are the future research directions?

2. Data Sources and Research Methods

2.1. Data Sources

To ensure the comprehensiveness and accuracy of the data, two literature databases, CNKI and Web of Science, were utilized as sources for this paper. Within the CNKI database, a total of 655 articles on "non-grain production of cultivated land" were searched without any restrictions on discipline or publication date. After manually excluding 309 articles that were irrelevant or from special journals lacking authors, institutions, or keywords (such as newspapers and notifications), 346 articles from journals, conferences, and academic papers in this field were obtained. In WOS, all available databases were used as literature sources, using subject headings such as "non-grain production of cultivated land", "non-grain cultivated land", "non-grain cropland", "non-grain arable land", "cultivated land non-grain conversion", "non-grain", and "non-grain production", with literature types limited to "Article" and "Review Article". The language was English, and the country or region was specified as "PEOPLES R CHINA". A total of 144 articles were identified, 77 of which were manually excluded. In the WOS, 67 articles by Chinese authors in this field were found. The search query for both databases was updated as of 31 December 2023. As the focus of this study was to analyze the research progress of NGPCL in China, the literature screened from the two databases was combined, resulting in a total of 413 articles in this field, which served as the sample for data analysis in this paper. The specific process of data screening is depicted in Figure 1.

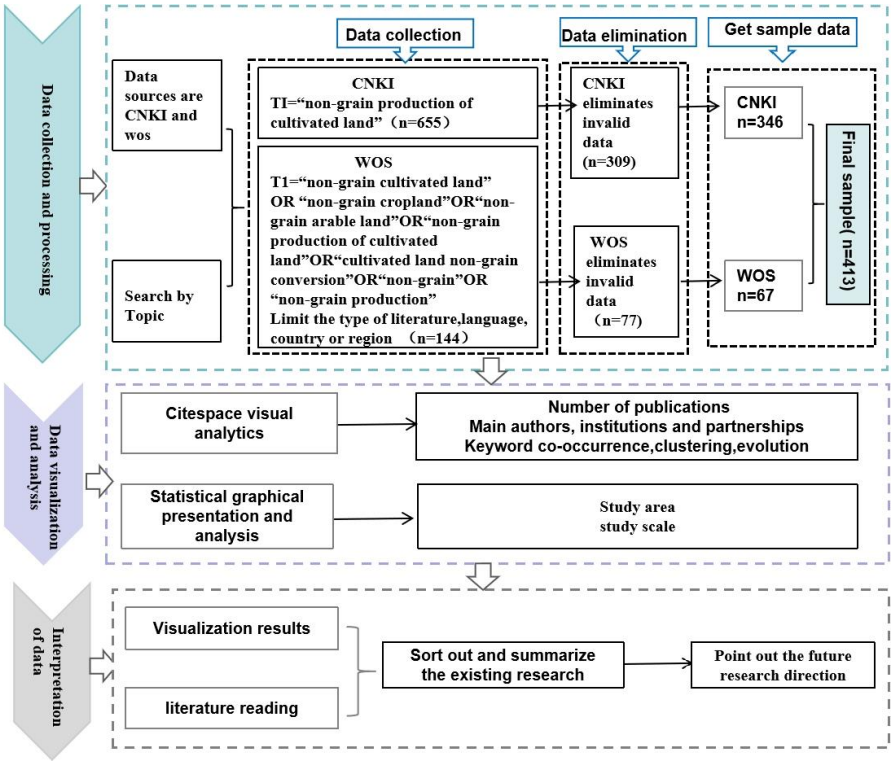

Figure 1. Research design and data collection flow chart.

2.2. Research Method

Bibliometrics is widely recognized as an effective method for efficiently studying published literature. It involves analyzing the structure, patterns, and characteristics of literature using mathematical and statistical methods to present, evaluate, and predict the current status and development of research in a specific field or discipline [41]. Commonly used software for bibliometric analyses include Ucinet 6.8, CiteSpace6.2.R6, VOSviewer v1.6.18, BibExcel v1.0.0, Gephi 0.92, and Pajek v5.1.8 [42]. Among these, CiteSpace software, developed by Dr. Chen Chaomei, has a unique advantage in visualizing and analyzing the

dynamics of disciplinary development and research frontiers [43]. Therefore, Citespace 6.2. R6 software was utilized as the analytical tool in this paper to generate a visual mapping by extracting the information of authors, institutions, and keywords in the sample literature, aiming at identifying the core group of authors, the network of research institutes, as well as the research hotspots and research context in the field of NGPCL. The visualization of node size and line thickness of the map was used to show the core influence of each element in the field and the degree of correlation between each other [44]. Furthermore, the temporal and spatial distributions of the target domains were also visualized through literature induction and statistics using mapping software such as Origin and ArcGIS, thereby compensating for the limitations of bibliometric software.

The research design and workflow of this paper can be divided into three steps: data collection and processing, data visualization analysis, and data interpretation. The first step primarily involves data collection and processing. The second step is focused on data visualization analysis. The data obtained from the first step are imported into CiteSpace, where knowledge maps are generated and analyzed. These maps illustrate the number of published articles, authors, institutions, and keywords in the research field. Additionally, research scales and hotspots are visually presented and analyzed through inductive statistics. The third step involves data interpretation. Based on the visualization results and literature review, the existing research is sorted and summarized, and future research in this field is anticipated. The specific process is depicted in Figure 1.

3. Results

3.1. Research Characteristics of NGPCL

3.1.1. Temporal Changes and Evolutionary Relationships

From 2009 to 2023, the number of annual papers published about NGPCL demonstrated an overall fluctuating growth trend (Figure 2) with an annual growth rate of 28.09%. This indicates that relevant research on NGPCL is gradually gaining prominence.

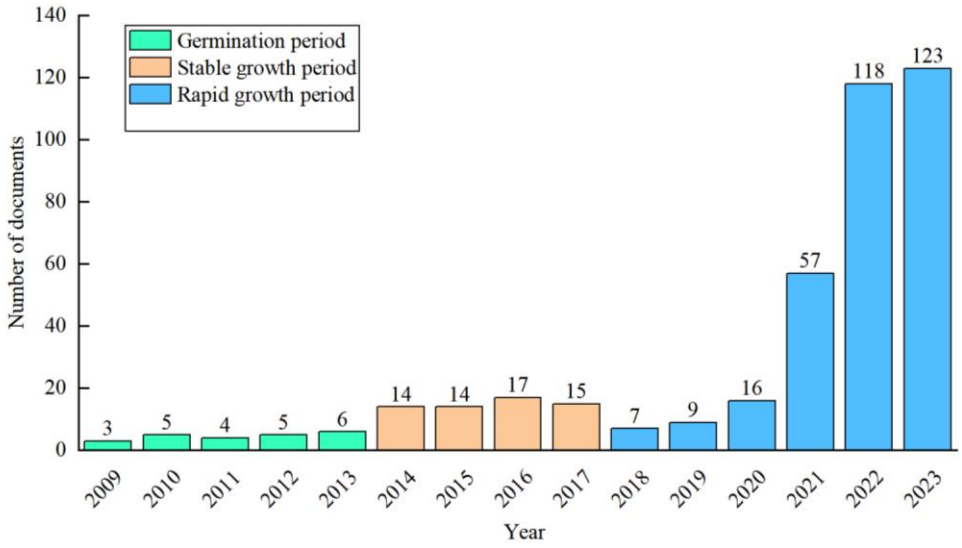

Figure 2. The statistics for the annual number of publications from 2009 to 2023.

This study classifies China's research on the NGPCL into three phases based on the number of publications from 2009 to 2023: 2009–2013, 2014–2017, and 2018–2023. The period from 2009 to 2013 can be considered the initial stage, which is characterized by a small number of publications and an average annual publication rate of less than 5. During this stage, researchers focused mainly on describing the phenomenon of non-grains in farmland transfer and their impact on food security. From 2014 to 2017, there was a steady growth in research activity with an average annual publication rate of 15 papers, showing an increase compared to the previous period. This may be attributed to the increased attention of

scholars on farmland transfer and the NGPCL following the issuance of *the Opinions on Guiding the Orderly Transfer of Rural Land Management Rights for Developing Moderate Scale Agricultural Management* by the General Office of the State Council in 2014. Research during this period mainly focused on exploring the driving mechanism of farmland transfer to NGPCL. The period from 2018 to 2023 witnessed rapid growth, with a total of 330 papers published in eight years, accounting for 79.9% of the sample literature. The average annual publication rate during this period was 55 papers. There was an initial decrease in the number of papers compared to the second stage, which was followed by a rapid increase. This pattern may be attributed to two documents that presented different attitudes toward the NGPCL: *the Summary of the proposal to differentiate between "non-grain" and "non-agricultural" cultivated land to protect China's food self-sufficiency* by the Ministry of Land and Resources in 2016 and *the Opinions on Preventing Non-grain Production and Stabilizing Grain Production in Cultivated Land* by the General Office of the State Council in 2020. During this stage, research focused on portraying the pattern, analyzing the driving factors, and exploring the governance mechanisms of the NGPCL. Overall, the attention of scholars in this area aligns with the documents issued by government departments on the NGPCL, forming a progressive relationship from describing the phenomenon to analyzing the driving mechanisms and then exploring the pattern and governance mechanisms.

3.1.2. Spatial Distribution and Its Correlation

Distribution and Connection of High-Yield Authors

In Figure 3, the collaborative network map of authors illustrates the distribution of articles among authors and the strength of cooperative relationships between them. Larger nodes denote authors with a greater number of publications, while thicker lines signify stronger cooperation between authors and vice versa [42]. Upon thorough analysis of this map, primary authors and major collaborating teams in the NGPCL field can be identified. Overall, there are 1014 researchers involved in this field, 25 authors have published more than three papers on the topic, and 87 authors have published more than two papers on the topic. Notably, 902 authors contributed only one paper, representing 88.5% of the total, indicating limited long-term attention from experts to the field.

Figure 3. Map of the collaborative network of authors.

According to the number of publications, the five most influential scholars in this field are Yinjun Chen, Xiaoyan Yi, Daolin Zhu, Muye Gan, and Zhiyuan Zhu (Table 1). Among them, Yinjun Chen from the Institute of Agricultural Resources and Regional Planning at the Chinese Academy of Agricultural Sciences stands out as the most prolific author, dedicating significant time and attention to this field. Xiaoyan Yi from the same research team extensively studied the relationship between farmland transfer and NGPCL, offering detailed analyses of prevention and control measures. Daolin Zhu, from China Agricultural University, focused on the impact mechanism of farmland capitalization on NGPCL. Muye Gan from Zhejiang University focused on the performance of different types of NGPCL, while Zhiyuan Zhu from Northwest Agriculture and Forestry University explored the spatial–temporal evolution, driving factors, and simulated spatial processes of NGPCL. Regarding cooperative relationships among authors, several groups demonstrate close collaboration with seven networks comprising more than five individuals. However, many groups have only two or three collaborations or pursue independent research. The two core cooperation networks are the team led by Muye Gan, which predominantly publishes English literature, and the team led by Yinjun Chen, which focuses on Chinese literature. However, such cooperation mainly occurs within the same unit or research institution, lacking cross-institutional and cross-unit collaboration.

Table 1. Number of papers published by high-yield authors and related information.

The Number of Papers Published	High-Yield Authors	The Year of Papers Published	Attentive Focus	The Types of Papers Published	The Institution and Region of the Author
6	Yinjun Chen	2010–2013, 2023	The relationship between farmland transfer and the NGPCL; the difficulties and measures for preventing and controlling NGPCL	The Chinese literature	The Institute of Agricultural Resources and Regional Planning at the Chinese Academy of Agricultural Sciences (Beijing)
4	Xiaoyan Yi	2010–2012	The relationship between farmland transfer and the NGPCL; the difficulties and measures for preventing and controlling NGPCL	The Chinese literature	The Institute of Agricultural Resources and Regional Planning at the Chinese Academy of Agricultural Sciences (Beijing)
4	Daolin Zhu	2021, 2023	The impact mechanism of farmland capitalization on the NGPCL	The Chinese literature	Beijing (Beijing)
3	Muye Can	2019–2020	The performance of different types of NGPCL	The foreign language literature	Zhejiang University (Hangzhou, Zhejiang)
3	Zhiyuan Zhu	2022	The spatial–temporal evolution, driving factors, and simulated spatial processes of NGPCL	The foreign language literature	Northwest Agriculture and Forestry University (Yangling in Shaanxi province)

Distribution and Connection of High-Yield Research Institutions

In Figure 4, the collaborative network map of research institutions illustrates the distribution of articles among institutions and the strength of the cooperative relationships between them. Larger nodes denote institutions with a greater number of publications, while thicker lines signify stronger cooperation between institutions and vice versa. Overall, numerous research institutions, primarily universities and scientific research institutes, are concerned with NGPCL. Core scientific research institutions such as Zhejiang University, China Agricultural University, the Chinese Academy of Sciences, Nanjing University of Finance and Economics, and Hohai University, alongside the Ministry of Natural Resources, play pivotal roles in this field. These institutions are distributed across various regions of the country with Hangzhou, Beijing, and Nanjing serving as key locations.

Figure 4. Map of the collaborative network of research institutions.

Regarding institutional cooperation, several major collaborative relationships have formed with core research institutions acting as bridges. This underscores the significant scientific research strength and influential role of these core institutions in the NGPCL field. However, apart from these core teams, most other research organizations maintain independent research endeavors. Additionally, as NGPCL has gained prominence in China, several foreign research institutions have recently joined the core team, collectively focusing on this issue. This trend suggests a growing inclination toward cross-regional and international cooperation among research institutions studying NGPCL.

Research Scale and Hotspot Region

The research scales for the phenomenon of NGPCL are primarily classified into national, provincial, cross-regional, city and county, and other scales. Cross-regional scales refer to those that span multiple cities and counties, while other scales refer to reviews or studies that do not specify the study area [44]. During the statistical process, it was observed that the literature in the WOS predominantly focuses on macroscale research conducted at the national and provincial levels. In contrast, the literature in the CNKI provides more comprehensive coverage, including research at both the national and provincial macroscale levels as well as mesoscale research across regional levels and microscale research that focuses on city and county levels. The published literature demonstrates a relatively balanced distribution of studies across all scales, except for the cross-regional level, where fewer studies are found (Figure 5). This suggests that the research in this field has produced fruitful results. However, more than 20% of the articles lack a clear research area, which undermines the practical significance of their conclusions. Furthermore, there is a lack of research conducted across multiple cities and counties, which hampers the coordinated implementation of governance for NGPCL land in different regions and presents certain limitations.

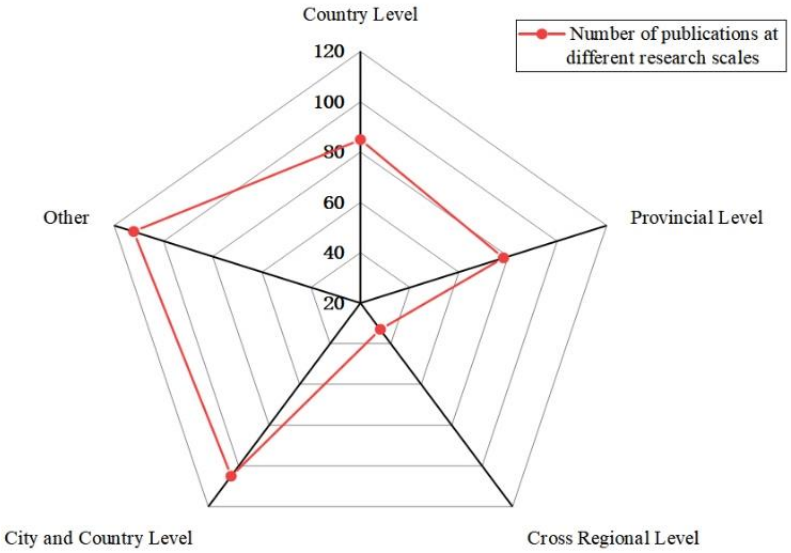

Figure 5. Distribution of study scales.

The research areas within the literature sample, excluding national and non-research areas, were categorized and enumerated by province to investigate the research hotspots of NGPCL in China. ArcGIS 10.8 was utilized to spatially visualize the frequency of occurrence of each province in the statistical sample literature and generate a map depicting the regional distribution of current research on NGPCL in China (Figure 6). Figure 6 shows that Henan and Zhejiang receive the most attention regarding the issue of NGPCL, which are followed by Sichuan, Shandong, and Jiangsu. The research does not include Taiwan, Hong Kong, or Macao. In terms of spatial distribution, the research is predominantly concentrated in the central and eastern regions, followed by the southwest region, while the northwest region has attracted the least attention. As a result, it fails to comprehensively reflect the current situation of China's NGPCL.

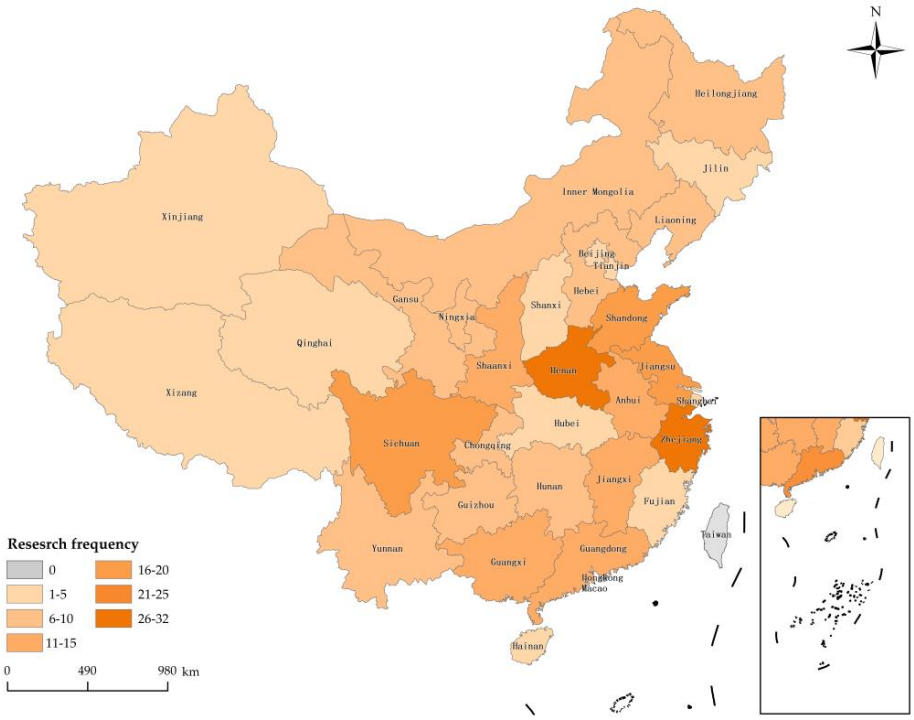

Figure 6. Distribution of the study region (review and approval number for drawings GS(2020)4619; the base map has not been modified).

3.2. Research Hotspots and Evolutionary Paths

3.2.1. Research Hotspot

Keywords Co-Occurrence

In the keywords co-occurrence map, the size of a node indicates the frequency of occurrence, while the centrality of a node indicates the strength of its relationship with other keywords in the graph [45]. The three largest nodes in the map are NGPCL, food security, and farmland transfer, with centrality values of 0.25, 0.5, and 0.24, respectively (Figure 7). This indicates that these three keywords are closely related and play a central and bridging role in the co-occurrence network map, representing the core and theme of the research. Other keywords with a high frequency of occurrence in larger nodes suggest that research on NGPCL in China from 2009 to 2023 should focus on topics such as cultivated land, cultivated land protection, countermeasures and suggestions, influencing factors, driving mechanisms, rural revitalization, and grain production.

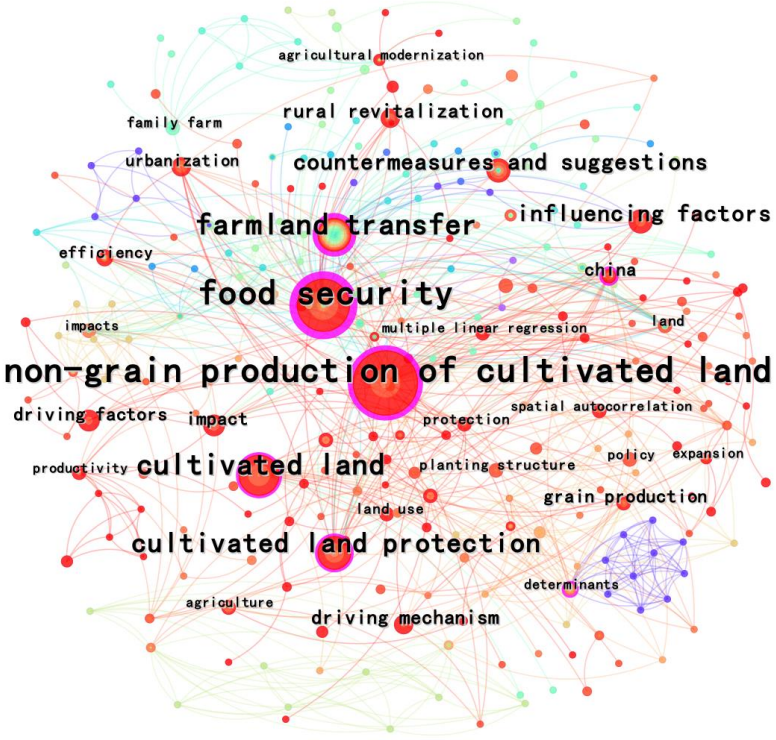

Figure 7. Map of the keywords co-occurrence of NGPCL.

Keyword Clustering

Using a statistical clustering method based on the co-occurrence of the keywords NGPCL, we generated 11 clusters of keywords, as shown in Figure 8. It is generally accepted that clustering results with Q > 0.3 and S > 0.5 are considered reasonable [46,47]. In this study, the Q-value is 0.7345, and the S-value is 0.9176, indicating that the clustering results are robust. By combining the results of the keyword clustering of NGPCL in Figure 8 and the keyword clustering information in Table 2, the research topics in this field can be divided into three categories.

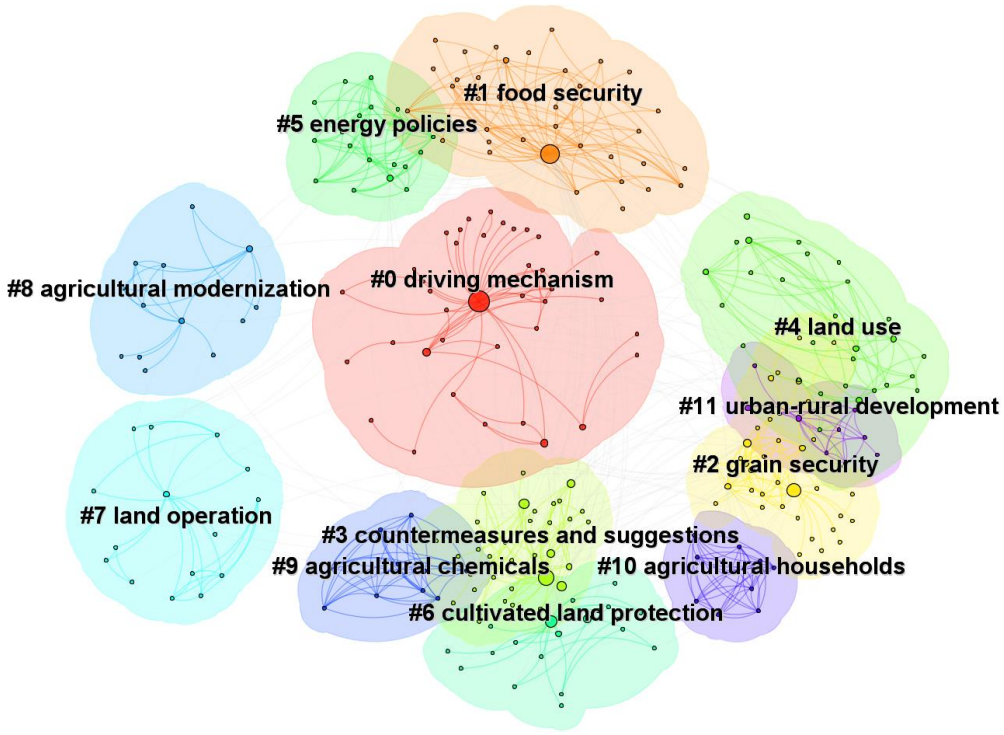

Figure 8. Map of the keywords clustering of NGPCL.

Table 2. Keyword clustering information of NGPCL research in China from 2009 to 2023.

Cluster Number	Cluster Name	Cluster Size	Outline	Average Year Cited	Co-Occurrence Keywords with Frequency Ranking of 1–5 in Each Keyword Cluster
#0	driving mechanism	38	0.91	2020	driving mechanism; non-grain cultivated land; grain production; cultivated land; non-grain production
#1	food security	37	0.969	2016	land circulation; circulation; farmland circulation; food security; non-food
#2	grain security	34	0.844	2020	spatial autocorrelation; grain security; cultivated land; grain production; non-grain production
#3	countermeasures and suggestions	35	0.877	2015	countermeasures and suggestions; influencing factors; farmland transfer; land transfer; non-food
#4	land use	20	0.838	2022	grain production; cultivated land; non-grain production; non-grain production of cultivated land; land rent
#5	energy policies	20	0.957	2017	biofuel; energy policies; renewable energy; land use change; food supply
#6	cultivated land protection	20	0.891	2018	cultivated land protection; cultivated land; land management; land transfer; rural revitalization
#7	land operation	15	0.915	2021	price; land operation; agricultural mechanization services; marginal land; by-production technology
#8	agricultural modernization	13	0.977	2016	agricultural modernization; family farm; industrial and commercial capital; farmer; ordinary farmer
#9	agricultural chemicals	10	0.99	2018	agricultural chemicals; agricultural structural adjustment; labor transfer; environmental management; ecological civilization pilot zone
#10	agricultural household	10	0.975	2010	agricultural households; income-source diversification; off-farm employment; China
#11	urban-Urban–rural development	10	0.937	2017	urban-rural development; smallholder agriculture; Sentinel-1; Sentinel-2; cropland abandonment

(1) Research on the historical background of the phenomenon of NGPCL. Keyword clusters for this research area include #5 energy policies, #7 land operation, #8 agricultural modernization, and #11 urban–rural development. The topic of "three rural issues" has always been a key concern for the State. With the rapid development of urbanization [48] and the comprehensive promotion of rural revitalization strategies [23,49], government departments have been encouraging industrial and commercial capital to flow into rural areas, establish family farms, promote agricultural by-product technology, and provide agricultural machinery services [39,50]. These efforts aim to improve smallholder farmers' agricultural production efficiency, with farmers as the main managers, and develop modern agriculture. While these measures have contributed to increased farmers' income and the development of the rural economy and are conducive to the coordinated development of urban and rural areas, they have also led to changes in cultivation practices and the abandonment of cultivated land [51]. In addition, to address the issues of excessive energy consumption and environmental pollution, the Chinese government has introduced incentives for non-grain bioethanol renewable energy, such as subsidies for the cultivation of non-grain raw materials [52].

(2) Research on the impact of the NGPCL. The keyword clusters associated with this research area included #1 food security, #2 grain security, #4 land use, #9 agricultural chemicals, and #10 agricultural households. Scholars are currently focusing on three aspects of its impact: the economic benefits for rural households, food security, and the ecological environment. Regarding the economic benefits for farmers, most scholars contend that NGPCL plays a crucial role in increasing the income of management bodies and bolstering the resilience and adaptability of farmers' livelihoods [53,54]. However, some scholars argue against a positive correlation between the scale and type of NGPCL and farmers' welfare [55,56]. From the perspective of food security, the focus primarily lies in its detrimental impact. Most scholars believe that NGPCL will affect soil microorganisms [57], soil organic matter [58], soil pH [59], soil texture [24], soil health [60], plow layer [61], fragmentation of cultivated land [62], and cultivated land quality [24,63,64], thereby endangering national food security [65,66]. Nevertheless, a few scholars perceive the NGPCL as a crucial support for implementing the concept of the "big food view" and a necessary step toward transitioning from grain security to food safety [67]. Considering the ecological environment, compared with traditional grain production, certain "non-grain" production necessitates increased inputs of agrochemicals such as plastic film, pesticides, and fertilizers. This can result in heightened soil pollution and carbon emissions [18,68] as well as a decline in farmland biodiversity, posing a threat to the ecological environment [64,69]. However, some scholars have argued that NGPCL generates positive externalities by improving the regional environment and enhancing the diversity of farmland ecosystems [20,70]. It is evident that the impact of NGPCL on cultivated land is both positive and negative, constituting a complex issue.

(3) Research on the driving mechanism, prevention, and control strategy of NGPCL. Key clusters of keywords in this research area include the #0 driving mechanism, #3 countermeasures and suggestions, and #6 cultivated land protection. Scholars have suggested that the driving mechanism behind NGPCL is complex and diverse. However, through detailed exploration, the driving factors can be summarized into three aspects. First, the behavioral habits, logic of action, and psychological expectations of farmers, who are the most important and direct management bodies of cultivated land use, play a fundamental role in determining whether cultivated land is used for non-grain purposes [71–73]. Second, the conditions of cultivated land, such as soil fertility [74], field slope [15], field shape, geographical location [75], and water source conditions [76], are closely related to the phenomenon of NGPCL. These factors are the most direct micro-objects of agricultural operations. Finally, socioeconomic factors such as economic income [39,77], economic growth [51], regional economic development [17], and land system policies such as land transfer and grain subsidies are external driving forces that promote the adjustment of agricultural structure and the utilization of cultivated land for "non-grain" purposes [26,78–82].

The goal of identifying the mechanisms driving NGPCL is to propose locally adapted preventive measures based on the study's findings. Current research has led to the formulation of comprehensive prevention and control measures such as theoretical guidance, system guarantees, path planning, and technical support. This includes establishing the concept of the "big food view" and a multidimensional security pattern [20,83] as well as implementing a cultivated land protection system of the "trinity" of quantity, quality, and ecology [84]. Additionally, various mechanisms, including "non-grain rights" transactions [23,33], regional economic compensation [15], credit systems for cultivated land damage [85], risk assessments of NGPCL [86], zoning control [87,88], step-by-step reclamation of NGPCL by planting grain crops [89], and special reclamation of NGPCL [11], should be explored to prevent or curb the phenomenon of NGPCL. Utilizing remote sensing monitoring [90], intelligent protection of cultivated land [91], and multiple cropping and fertilization technology for NGPCL can also facilitate monitoring and management of the entire process of cultivated land use to ensure its rational utilization [92].

3.2.2. Evolutionary Path

Using the first publication year of keywords related to NGPCL as the x-axis, a keyword time zone map of NGPCL spanning from 2009 to 2023 was created (Figure 9). This map not only dynamically portrays the evolution of research themes in this field but also accurately pinpoints emerging research trends in this area.

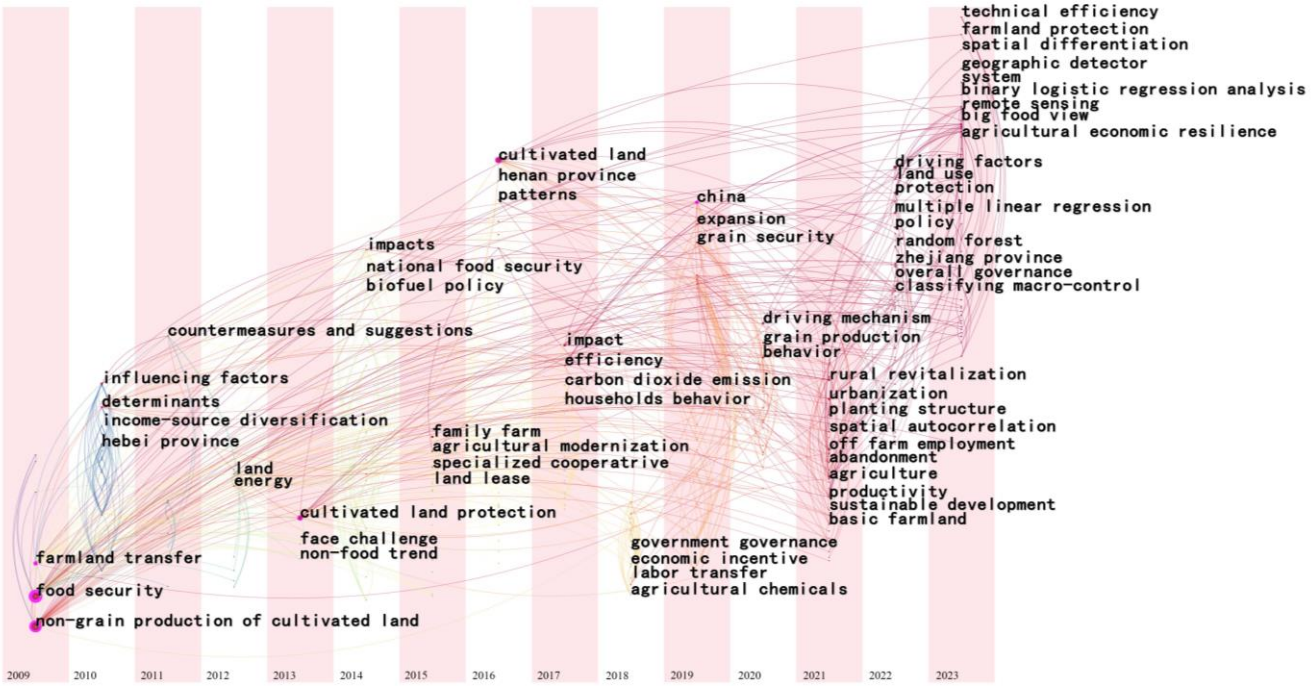

Figure 9. Map of the keywords time zone of NGPCL.

During the germination stage (2009–2013), the no.1 document in the central committee of 2009 emphasized "the establishment and improvement of a market for transferring land contract management rights and the development of organizations providing land transfer services". With the coordination of professional service agencies, rural land transfers have become widely common nationwide. The phenomenon of NGPCL in farmland transfer in Hubei and other regions, as well as the associated food security issues, has become the subject of significant scholarly discussion. During this period, scholars primarily conducted qualitative and macroscopic explorations of the trend of "non-grain" planting in farmland transfer and its impacts on food supply security.

During the steady growth phase from 2014 to 2017, scholars conducted field research and demonstrations in Henan Province as well as in select cities and counties within the province. They investigated the business models of new management subjects, such as family farms and professional cooperatives, emerging from farmland transfers. Scholars have also examined changes in farmers' behavior, land rents, and other driving mechanisms of the NGPCL. Food security concerns related to the NGPCL remained a focus of their attention. In 2014, the issuance of the *Guiding Opinions on Promoting the Healthy Development of the Biofuel Ethanol Industry* further encouraged the production of non-grain bioethanol. Consequently, this period also emphasized the non-grain cultivation of biological raw materials, the efficiency of non-grain biological raw material utilization, and carbon dioxide emissions. In summary, although the focus of the first two stages differed, it primarily revolved around the relationship between farmland transfer and the NGPCL.

With the state's shifting stance toward the "non-grain" use of cultivated land transitioning from relaxed to strict, scholars have engaged in a series of discussions on the NGPCL as an academic issue during the period of rapid growth (2018–2023). This subject has spawned numerous new research topics, which can be categorized based on keywords. The first type focuses on the historical background, including concepts such as rural revitalization and urbanization. The second category focuses on the impact of NGPCL, including keywords such as food security and agricultural chemicals. The third category concentrates on spatial patterns, driving factors, and prevention and control measures and involves terms such as spatial differentiation, spatial autocorrelation, driving mechanisms, driving factors, government governance, overall governance, sustainable development, and farmland protection. Over this period, several new research methods have been applied, including geographic detector, random forest, and binary logistic regression analysis methods. Overall, compared to previous periods, this era is marked by more concrete research content and the integration of modeling in research methods.

In 2023, the emergence of new keywords, namely, "big food view" and "agricultural economic resilience", opened up new avenues for scholarship. Therefore, it is likely that future research will focus on the governance of NGPCL from the perspective of the big food view and its impact on China's agricultural resilience [81,83].

4. Prospects and Discussion

4.1. Expanding the Spatial Scope and Examining the Trend of NGPCL at the Global, Regional, and Multiscale Levels

The agricultural industry is undergoing significant transformations as a result of globalization. One notable aspect is the growing trend of non-grain use of cultivated land, which, unfortunately, has not received adequate international attention. The exception to this is China, where the complex human–land relationship has prompted considerable focus on this phenomenon. Chinese scholars have primarily concentrated on the central and eastern regions with studies predominantly being conducted on a provincial scale. However, limited research has been conducted in the northwestern regions as well as on smaller scales such as townships and land parcels. Notably, since 2005, China's grain production has shifted from "south grain transfer to the north" to "north grain transfer to the south" [93]. Moreover, the specific use of cultivated land varies according to the characteristics of individual farming plots [94], resulting in different crop choices by operators. Therefore, future research should aim to expand the spatial scope and analyze the similarities and differences in the non-grain use of cultivated land in countries with varying economic development levels and human–land relationship structures from a global perspective. In China, it is essential to focus not only on non-grain use of cultivated land in major grain-producing areas in the central and eastern regions but also in different economic and geographic regions as well as in areas with a balance between grain production and marketing and major grain marketing areas. Additionally, it is necessary to refine the scale of the study to understand the behavioral characteristics and influencing factors of non-grain use of cultivated land in key areas from a more detailed perspective, such

as townships, administrative villages, natural villages, and land patches. Ultimately, this will facilitate the development of a comprehensive, multiscale research framework on the non-grain use of cultivated land.

4.2. Improving the Accuracy of Data Acquisition for Research Related to NGPCL

At present, the measurement of NGPCL relies primarily on two sources of data: household surveys or statistical yearbooks and remote sensing interpretation techniques. However, both methods have limitations. While household surveys and statistical yearbook data allow for large-scale studies, they do not provide detailed information on land patches and spatial distribution. Conversely, remote sensing interpretation data can capture the intricacies of land patches, but they are often affected by interference from objects with similar spectra or variations in the same object's spectra, necessitating accuracy checks [95,96]. To fully comprehend the scale and spatial distribution of NGPCL in China, it is essential to employ multidimensional data platforms such as the Google Earth Engine (GEE), GIS, and RS. Combining data from household surveys and statistical yearbooks improves the accuracy of the collected data. Moreover, when utilizing bibliometrics to evaluate research progress in this field, the choice of keywords for data retrieval can significantly impact the precision of the results. When searching the WOS database, it is crucial to consider the diverse range of English language used for NGPCL. To mitigate this issue, the authors engaged in extensive discussions and tested the search process. However, it is impossible to guarantee the absence of any omissions in the retrieval process. Therefore, it is crucial to consider how to accurately and intelligently obtain data when utilizing bibliometric methods, which is a problem worth addressing in the future.

4.3. Carrying out Spatiotemporal Simulations, Trend Predictions, and Risk Assessments for NGPCL

Currently, scholars primarily focus on the observed phenomenon and existing data when discussing the issue of NGPCL. However, it is crucial not to overlook the future evolution trend of NGPCL, as this should be the focus of academic research and the government's attention. To fulfill this objective, it is crucial to develop statistical models and spatial models to predict the scale of NGPCL in China. These models should be constructed based on an analysis of the generation mechanism and identification of driving factors in NGPCL hotspot areas. These models will be utilized to forecast and simulate the scale and spatial–temporal evolution process of NGPCL within a specific period in the future. Additionally, these models will aid in evaluating the associated risks. Although this approach has been applied to studies on farmland abandonment in other countries [97], it is important to clarify that farmland abandonment is not synonymous with NGPCL. Thus, the models cannot be mechanically applied to predict NGPCL. Two key points should be emphasized. First, when constructing the models, multiple factors, such as the level of economic development, agricultural modernization, market demand, cultivated land background conditions, farmers' behavioral characteristics, and policy interventions, must be considered. Moreover, regional heterogeneity should also be considered. Second, when conducting risk assessments, it is essential not only to estimate the risk of grain production capacity loss due to NGPCL but also to comprehensively evaluate socioeconomic risks, including changes in family structure, production organization forms, and rural social relations resulting from the livelihood responses of different business entities [98]. Additionally, ecological environmental risks such as the degradation of cultivated land quality, carbon emissions impacts, and agricultural landscape pattern changes should also be considered.

4.4. Focusing on Exploring Policy Design for the NGPCL from the Perspective of the Human–Land Relationship Structure

As a significant trend in the current change in the utilization of cultivated land in China, research on NGPCL has been extensive in various areas, including its background, influence, driving mechanism, prevention and control strategies. However, the primary objective of these studies was to design and implement policies aimed at safeguarding

cultivated land. The complexity lies in deciding whether to expedite the NGPCL process to promote diversification, transformation, and upgrading of the agricultural industry or to restrain the NGPCL trend to maintain food production security. This issue necessitates comprehensive consideration and balance rather than presenting a simplistic either/or choice. NGPCL is essentially the result of interactions between humans and land [23]. Therefore, for the policy design of NGPCL, it is essential to respect the diverse developmental needs of agricultural subjects and adhere to the principles of the market economy to stimulate innovation in agricultural production. Simultaneously, it is crucial to consider the multifunctionality of cultivated land and its varying basic conditions and to optimize its value through locally tailored utilization planning. The ultimate objective is to strike a balance between the diversified development of the agricultural industry and ensuring food production security, promoting the coordinated advancement of cultivated land protection and economic development, and achieving harmonious coexistence between humans and nature.

5. Conclusions

This study utilized the bibliometric method to visually analyze the spatiotemporal characteristics, research hotspots, and evolutionary trends of 413 sample articles in the field of NGPCL, which were retrieved from the CNKI and WOS databases. Future research directions in this field are also discussed and anticipated. The key findings are as follows:

The number of published papers in this field has undergone three stages: a germination period, a period of steady growth, and a period of rapid growth, showing an overall upward trend. Research on the NGPCL has gained increasing prominence, forming a progressive research context that evolved from describing the phenomenon to analyzing the driving mechanism and exploring the spatial pattern portrayal and governance mechanism.

The research institutions in this field exhibit the spatial characteristics of intercrossing among multiple institutions. They are primarily concentrated in universities located in the eastern regions, where the issue of "non-grain" is especially prominent. Additionally, scientific research institutes and national-level administrative departments in the capital city also play a significant role. This research primarily focused on the major grain-producing provinces in central and eastern China, which have a strained relationship between humans and land but superior agricultural conditions. However, little attention has been given to major grain marketing areas or grain production and marketing balance areas in northwest China, where the relationship between humans and land is more relaxed and agricultural conditions are poor. Existing research has focused on macroscale studies at the national and key provincial levels as well as microscale studies at the city and county levels. There is a lack of studies at the mesoscale, which involves cross-regional analysis as well as at the more microscale of towns, villages, and land patches, resulting in a lack of synergistic governance mechanisms.

The high-frequency keywords in this field are NGPCL, food security, and farmland transfer. Research hotspots have focused on the historical background, impact, driving mechanisms, and prevention paths of NGPCL. The research themes of farmland transfer and NGPCL are evolving.

In the future, research in this field should expand its spatial scope and examine the trend of NGPCL from a global, regional, and multiscale perspective. Efforts should be made to improve the accuracy of the obtained data and to conduct spatial and temporal simulations, trend predictions, and risk evaluations. Additionally, there is a need to explore policy design from the perspective of the human–land relationship structure and to deepen the research on NGPCL.

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