


## Review

# Research on Green and Low-Carbon Rural Development in China: A Scientometric Analysis Using CiteSpace (1979–2021)

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**Abstract:** Green and low-carbon rural development (GLRD) is becoming an important way to explore sustainable development in rural areas of China. It is significant for the sustainable development of the rural economy and of society to build a rural carbon sink system, advocate low-carbon emissions in rural areas, and promote the development of rural green industries and rural transformation. In this study, the existing knowledge system of GLRD was analyzed using CiteSpace. Keywords related to GLRD and their occurrence frequency were identified using keyword co-occurrence analysis. The knowledge evolution stages of GLRD were explored using citation burst analysis. Thus, the evolution of the research related to GLRD was revealed. The summary of Chinese GLRD-related research literature shows that: (1) according to the CiteSpace analysis, the GLRD research can be divided into three stages: starting, rising, and expanding and deepening; (2) GLRD research has focused on low-carbon development, green development, and then green and low-carbon integrated development, thus forming three major research content systems; (3) GLRD's research content gradually became rich, as over time, the research focus became increasingly prominent and research integration was gradually strengthened; (4) the GLRD literature still has some limitations, e.g., nonunified measurement standards, insufficient research depth and practical significance, and relatively weak innovative policy research; (5) future research should strengthen the scientific evaluation and prediction of rural green and low-carbon functions. The industrial development pathways and regional characteristic modes of GLRD should be further studied. Innovative GLRD policies should be proposed to provide a theoretical basis and decision-making reference for GLRD and construction.

**Keywords:** green and low-carbon; research hotspot; research stage; content system; China; rural area



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## 1. Introduction

With the rapid economic and social development of recent years, energy shortages and environmental degradation are the two major problems for urban and rural development [1,2]. Global warming is an ecological and environmental problem worldwide. Environmental disasters caused by global warming have changed how human society produces, lives, and consumes. It has raised concerns about reducing pollution and resource waste [3,4]. The United Nations Conference on Environment and Development has formulated some international rules for this purpose. The World Commission on Environment and Development (WCED) formally proposed a sustainable development strategy in its report “Our Common Future” published in 1987 [5]. The Rio Declaration of Environment and Development and Agenda 21 were presented at the Conference on Environmental Development in Rio de Janeiro, Brazil in 1992 [6]. The development of green and low-carbon measures has deepened due to continuously improved global carbon emission requirements [7–9]. China has put forward a series of major development

strategies as a positive response and made significant contributions to global green energy and low-carbon development [10]. In 2007, China set the goal of 20% energy conservation within five years. In 2020, China proposed the strategic goal of “striving to peak its carbon emissions by 2030 and achieving carbon neutrality by 2060” (i.e., the “dual-carbon” goal).

Studies on “green” and “low carbon” in China have received wide attention worldwide [11,12]. Rural areas are an important global source of greenhouse gas emissions and a huge carbon sink system with significant potential contributions to achieving the “dual-carbon” goal [13]. Therefore, agricultural and rural carbon emissions, carbon sinks, carbon reduction measures, and green development are becoming hot interdisciplinary research issues [14–16]. Particularly, green agriculture, green agricultural development, and low-carbon agriculture are the main research objects [17–19]. Green development evaluation and measurement, carbon emission accounting, and the influence mechanisms of quantitative studies are the mainstream research directions [20–22]. However, most existing research content involves field studies independent of rural “green” or “low carbon” [23]. Integrated research and analysis of green and low-carbon rural development (GLRD) are still lacking.

The GLRD concept is an indispensable part of China’s ecological civilization construction. It is one of the basic principles of rural revitalization in the new era [24]. Under the guidance of the “dual-carbon” goal, agricultural and rural development will certainly face new requirements and challenges. Green and low-carbon transformation is an important topic for future rural development. The GLRD literature is comprehensive and interdisciplinary. Thus, it is expected to become a new field of interdisciplinary attention in agricultural economics, rural geography, ecology and environment science, and ecological economics.

Citespace is mainly used to identify and demonstrate new situations and trends in scientific literature. It is a diversified, dynamic and practical software for visual analysis. Citespace can identify research progress, frontiers, and corresponding knowledge bases in a certain disciplinary field and facilitate reflection of the overall situation of this field [25]. In this study, a bibliometric analysis was conducted using CiteSpace combined with qualitative research to achieve a systematic review of the GLRD research literature during 1979–2021. This study included the following objectives: (1) to explain the emergence and occurrence of GLRD research keywords; (2) to divide research stages systematically; (3) to sort out the research content system; (4) to determine research trends. This study is intended to provide a reference for better determining research directions and concise research issues. The research findings can also provide a theoretical basis and decision-making reference for future GLRD and construction in China.

## 2. Materials and Methods

### 2.1. Research Methods

CiteSpace has obvious advantages in sorting out relevant research topics, research backgrounds, evolution processes, and other aspects [26]. This study used CiteSpace 5.8 according to the following process: keywords; professional terms; data collection; extraction of research frontier terms; time zone segmentation; threshold selection; visual display; visual editing; detection application. This study focused on the GLRD issues in China and can improve the objectivity of related research progress reviews [26].

### 2.2. Data Source

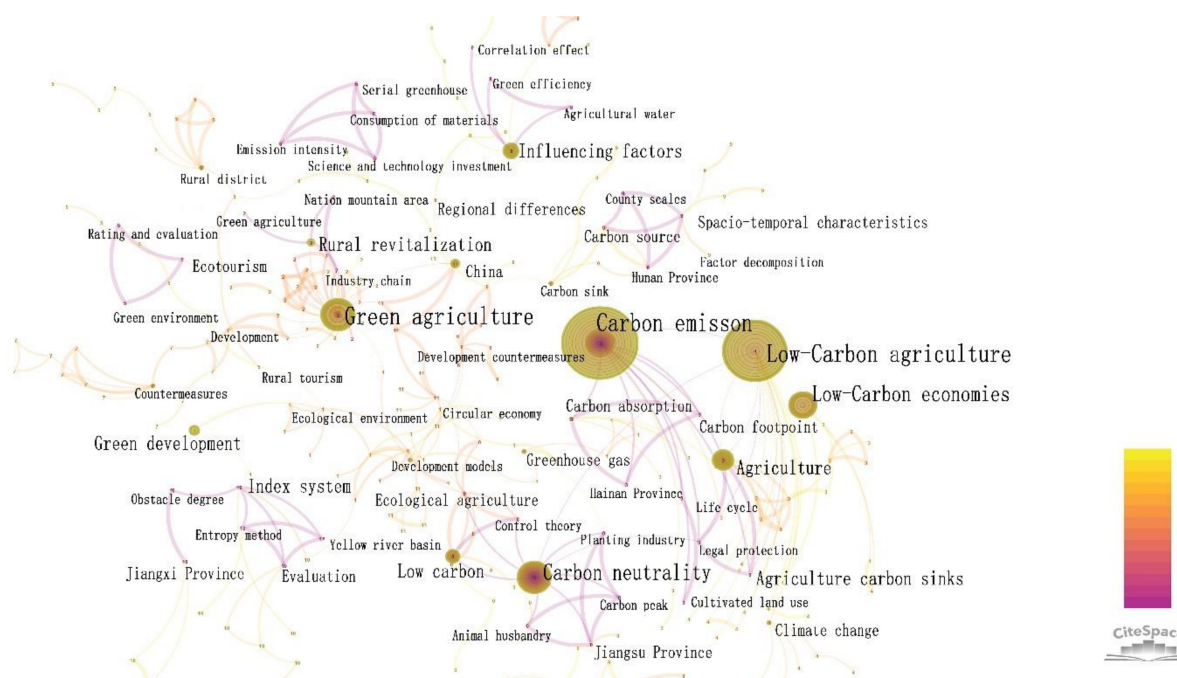
First, as the most important Chinese academic database in China, China National Knowledge Infrastructure (CNKI) was used to conduct advanced searches targeting the research objects. The keywords “green & rural area” and “low carbon & rural area” were searched on the CNKI data platform on 2 November. Then, 8787 articles were obtained. The secondary literature screening process was as follows. First, the advanced search was conducted in the CNKI database. The literature type was set as journal papers. Then, precise searches of directly related literature were conducted using “name” as the search condition.

CSCD and CSSCI are the sub-databases of CNKI, which only include high-quality articles. Therefore, they were selected as the literature sources. Precise literature searches were conducted for “low carbon”, “green”, “carbon emission”, “agriculture”, “rural area”, and “rural areas”. More than five references were selected from other core journals such as Agriculture Economy and World Agriculture. After book reviews, reports, and other irrelevant documents were excluded, a total of 1154 literature records were obtained. Then, CiteSpace was used to analyze keyword co-occurrence, burst, and temporal evolution based on the 1154 articles. The main evolution characteristics of GLRD research were summarized through visual analysis.

### 3. Knowledge Graph Analysis Using Citespace

### 3.1. Main Research Interests in GLRD: Keyword Co-Occurrence Analysis

The co-occurrence network of GLRD's keywords in 1979–2021 (Figure 1) shows that the keywords with higher frequency include low-carbon agriculture (231 times), carbon emissions (230 times), carbon neutrality (133 times), influencing factors (128 times), rural revitalization (112 times), and green agriculture (101 times). Other high-frequency keywords included index system, low-carbon economy, green development, agricultural economy, agricultural production, ecological agriculture, agricultural carbon sink, development mode, regional differences, development countermeasures, low carbon energy, low carbon consumption, energy conservation and emission reduction, agricultural pollution, farmland use, organic agriculture, and biogas engineering. The involved regions mainly included Jiangsu, Jiangxi, and Henan. Only 15.8% of the literature had keywords with more than five occurrences. This indicates that the keywords in GLRD literature have low centrality and exhibit a significant diversification phenomenon.



**Figure 1.** Co-occurrence network analysis of keywords in GLRD literature.

The keyword burst intensity of GLRD literature in 1979 (Figure 2) shows that the sudden staged characteristics of the keywords bursting were significant. The year 2007 was taken as the main node. Before 2007, legal guarantee, plant protection, material consumption, county scale, emission intensity, cybernetics, carbon absorption, and other keywords were research hotspots. Since 2008, low-carbon economy, agriculture, and green development have become the latest hotspots of direct GLRD research, with the burst intensity reaching 19.88, 47.72, and 20.85, respectively.



**Figure 2.** Keyword burst intensity in GLRD literature.

### 3.2. Study Stage Division

The background of international rules and the important policies of China were sorted out (Figure 3). Combined with the deduction of the knowledge evolution process of GLRD research based on the time zone distribution of keywords in CiteSpace (Figure 4), the GLRD research stage can be divided into the starting, rising, and expanding and deepening stages (Figure 5).

#### 3.2.1. The Starting Stage: 1979–1991

In the 1980s, the concept of sustainable development occurred, and the “green revolution” was launched abroad [27]. Due to the reform and opening up, agricultural production reforms were triggered in China’s rural areas, focusing on areas such as ecological agriculture and low-carbon agriculture. The research on GLRD mainly focused on exploring agricultural production and reform. There was a small amount of research content on green system construction and agricultural development, the experience and lessons from the “green revolution”, and ecological issues in rural agricultural production. In China’s rural areas, the development of biogas as biomass energy was intended to reduce carbon dioxide emissions, thus starting the research on rural low-carbon development. In this stage, the research scope and horizon were relatively narrow, and the investigation mainly focused on the research method.



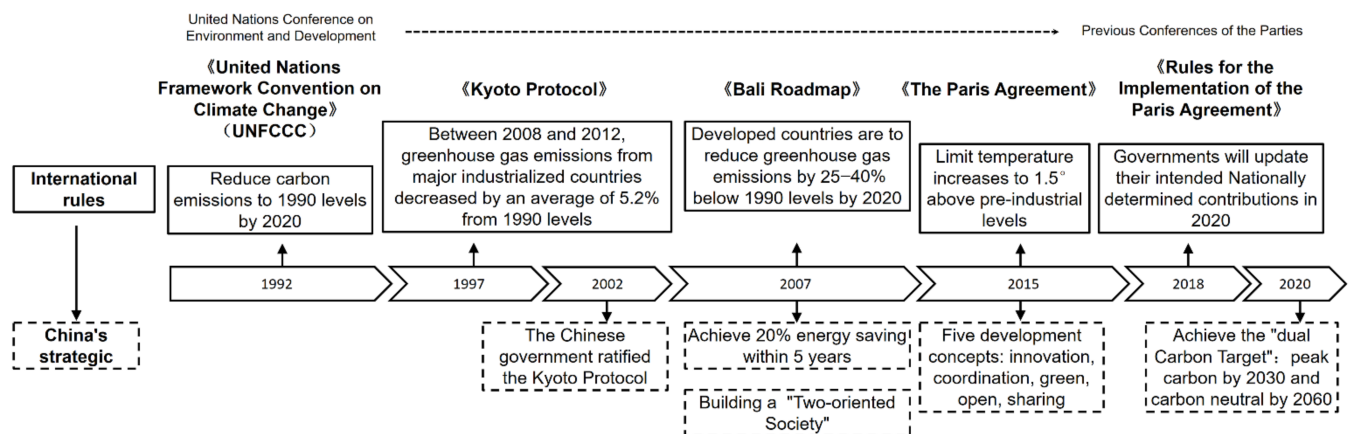


Figure 3. Evolution of international rules and domestic development strategies.

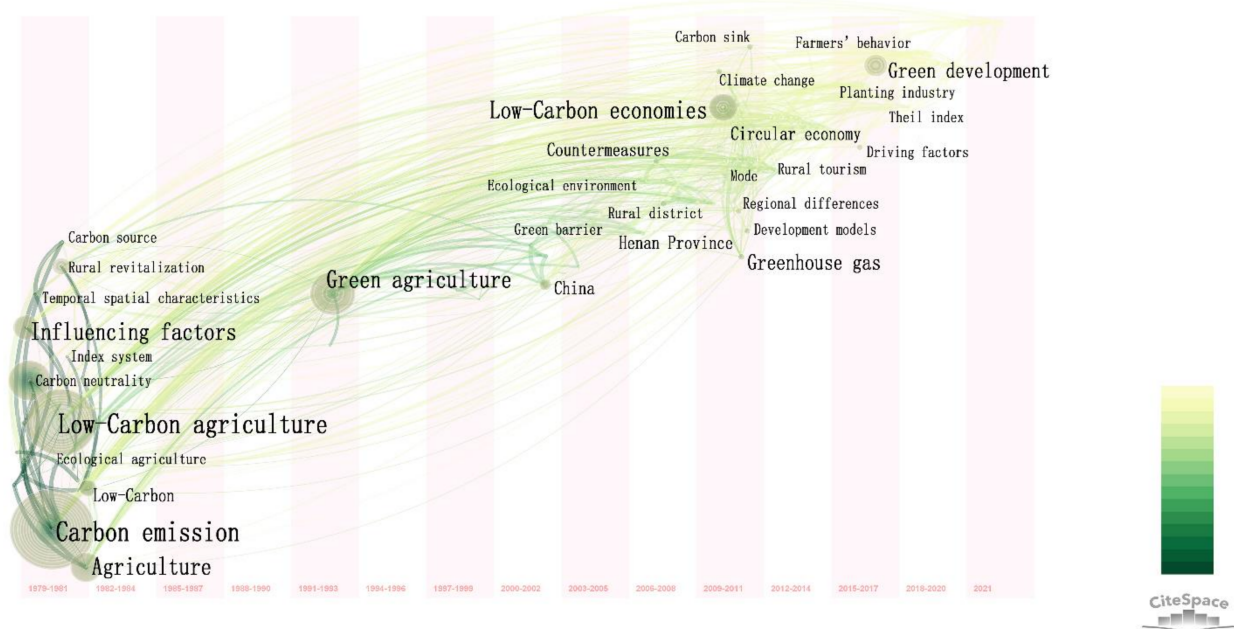
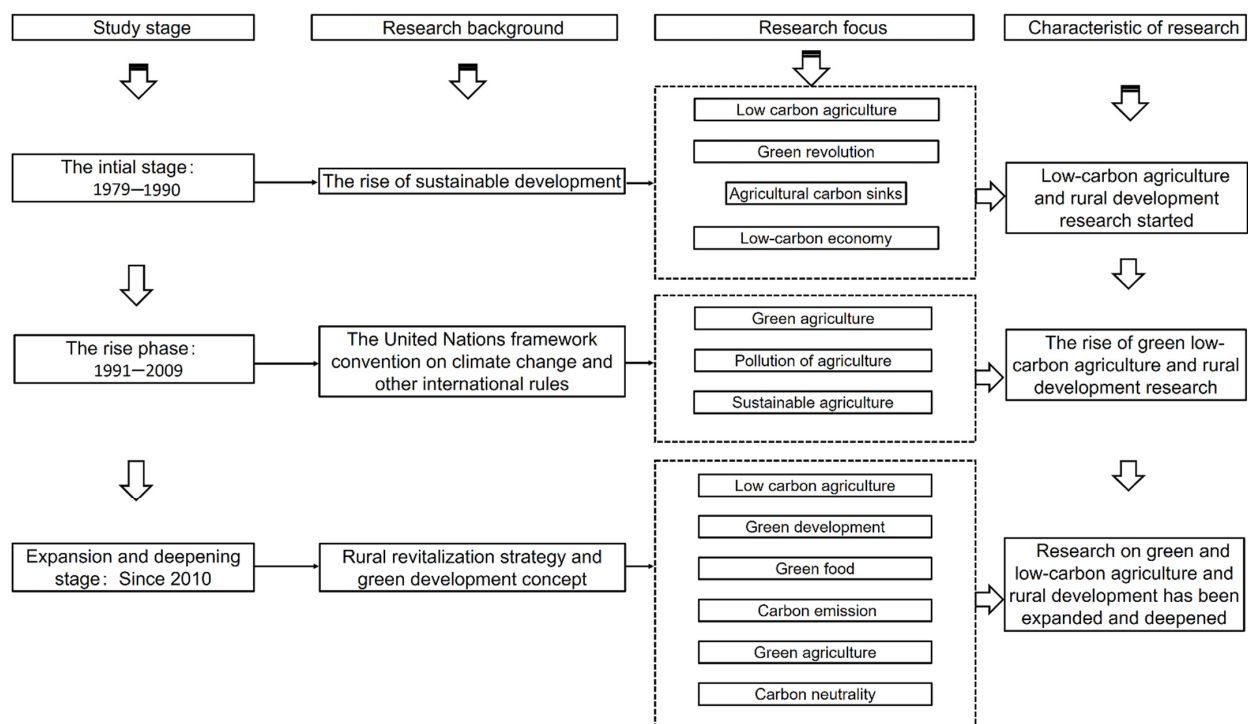


Figure 4. Time zone distribution of keywords in GLRD literature.

### 3.2.2. The Rising Stage: 1992–2007

From the United Nations Framework Convention on Climate Change in 1992 to the Kyoto Protocol in 1997, the quantitative emission reduction targets for global carbon emission requirements have been gradually clarified. This has greatly impacted China's industrialization, urbanization, and marketization. Rural green development and construction have gradually received attention in China. In addition, with China's accession to the WTO in 2001, "green barriers" have greatly impacted agricultural production. In this stage, green agriculture was the main research hotspot. Other related hotspots include sustainable agriculture, agricultural pollution, and development countermeasures. The overall research level was relatively macroscopic, focusing on development strategy research at the national level. The research area was mainly in the developed eastern provinces. There was also some research on ecosystem carbon emissions in some special geographical environment areas. In this stage, qualitative research methods were mainly the above research as well as comparative analysis and countermeasure analysis. Quantitative analysis had rarely been conducted at this stage.



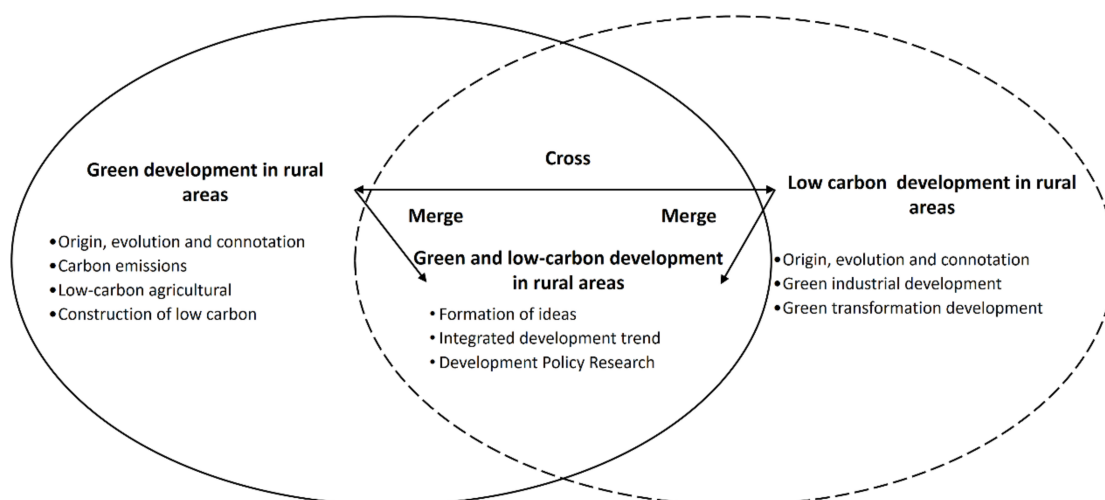
**Figure 5.** Division of GLRD research stages.

### 3.2.3. The Expanding and Deepening Stage: 2008–Present

In 2007, the adoption of the Bali Road Map resolution tightened carbon emission requirements. China actively responded to the relevant requirements and put forward the development strategy of establishing a “two-oriented society”. During this period, with the deepening of the development strategies of new socialist countryside construction, beautiful countryside and rural revitalization, China’s rural development entered a comprehensive transformation stage. The GLRD research expanded to carbon emission, low-carbon agriculture, carbon neutrality, and green development. Low-carbon agriculture has high relevance in Chinese academic circles. The hotspots emerged in 2010 and 2011. Green agriculture is a modern mode characterized by providing green, safe, high-quality, and high-technology content of agricultural products, and it has become a hot topic for further refinement research [28,29]. In addition, the intersection of rural green, low-carbon, and ecological technology systems promoted the research integration trend among them. The research scope mainly lay within developed coastal areas. Among them, large regional-scale research of urban agglomerations, economic belts, and provinces was the main focus of the research content [30]. In these studies, quantitative analysis methods such as model analysis and the global ML index method were most often used [31].

## 4. Research Content System for Green and Low-Carbon Rural Development

Research on GLRD has experienced low-carbon, green, and green–low-carbon integrated development research stages. Thus, three research content systems were formed (Figure 6). There is no obvious chronological order between low-carbon and green development research. These two research types both have green development and low-carbon development of agriculture as their main foci, with certain intersections in independent systems. However, with the introduction of various green and low-carbon policies in rural areas, the integration trend of the two major studies is significant.



**Figure 6.** Research content systems of green and low-carbon rural development.

#### 4.1. Research on Rural Low-Carbon Development

##### 4.1.1. Origin, Evolution, and Connotation of Rural Low-Carbon Development

The development of the “low-carbon” concept spawned from the 2003 UK Energy White Paper “the future of our energy—creating a low carbon economy”. It became popular worldwide after being used by the World Bank in 2006. A low-carbon economy with low energy consumption, low material consumption, low emissions, and low pollution is the new option for economic development in the 21st century [32]. It has led to the development of low-carbon cities, industries, buildings, and other fields. Rural low-carbon development includes low-carbon agricultural development, low-carbon rural living environment, low-carbon tourism development, and other content systems. Among them, low-carbon agricultural development is the most important component, which has the core goal of using agroecosystems to mitigate and adapt to climate change [33]. The specific pathways of rural low-carbon development includes reducing energy consumption, pollution, and emissions as well as increasing carbon sinks [34].

##### 4.1.2. Research on Rural Carbon Emissions

The research objects of rural carbon emissions mainly include agricultural and rural living environment carbon emission research. Main rural carbon emission sources include agricultural and residential living systems. The former mainly includes the energy consumption of agricultural machinery and the use of chemical fertilizers and pesticides, whereas the latter involves project construction processes, construction operation and management of its energy consumption, and transportation and its energy consumption [35]. Rural heating energy consumption is also significant [36]. Currently, the accounting method for agricultural carbon emissions mainly adopts the inventory preparation method, carbon emission coefficients, the LMDI method, and the Environmental Kuznets Curve (EKC) [37]. In addition, carbon emission measurement includes not only large-scale regional carbon emission research from national to interprovincial levels and from provincial to municipal levels, but also small-scale carbon emission research within specific spaces, such as residential communities and rural settlements. Due to the huge differences in production conditions and resource endowment, agricultural economic development levels, agricultural structures, and agricultural production modes vary greatly among cities [38]. This leads to significant differences in the spatial and temporal distribution of agricultural carbon emissions. Reducing rural carbon emissions mainly includes strengthening rural ecosystem carbon sinks and reducing agricultural carbon emissions. Studies of carbon sinks in ecosystems (such as forests, wetlands, and farmland) have been the focus of research in recent years, e.g., forest ecosystem carbon revenue and expenditure as well as

the regional distribution and reserve changes of soil-organic carbon [39,40]. The emission reduction ideas and specific suggestions to drive green agricultural transformation with low carbon include increasing carbon constraint indicators in combination with agricultural and rural development planning, accelerating the construction of agricultural carbon emission accounting methodology, actively developing agricultural carbon markets, and using financial measures to promote low-carbon agricultural technologies [13].

#### 4.1.3. Research on Rural Low-Carbon Agricultural Development

Low-carbon agriculture is modern agriculture with “low consumption, low emission, and low pollution”. It meets the objective requirements of controlling agricultural greenhouse gas emissions and slowing down global warming [41]. The low-carbon agricultural economy is developing into a new mode and concept that affects the “low-carbon” of China’s agricultural industry chain [42]. However, it also faces some problems, such as low agricultural modernization level, difficulties in large-scale land production, weak agricultural infrastructure, lack of scientific and technological innovation capabilities, and extensive agricultural production modes [43,44]. The research content involves research on the transformation pathways of promoting low-carbon agricultural development [45], low-carbon agricultural development modes under different rural regional types, and low-carbon innovation of agricultural enterprises. The development pathways of low-carbon agriculture include transforming agricultural development modes, promoting agricultural energy conservation and emission reduction technologies, reducing agricultural non-point source pollution, and improving rural energy utilization efficiency [46]. The main factors affecting low-carbon innovation of agricultural enterprises include low-carbon innovation cost, the increase of low-carbon innovation revenue, and governmental regulation [47].

#### 4.1.4. Research on Rural Low-Carbon Construction

Under the wave of low-carbon town construction, research on low-carbon rural development (e.g., low-carbon rural construction, tourism development, rural planning, communities, industry and energy-carbon residential development and design) is gradually emerging. The pathways of low-carbon rural construction mainly include expanding rural carbon sinks and reducing rural carbon sources. Low-carbon rural tourism advocates low-carbon consumption, reduces resource consumption, and pays attention to low-carbon rural landscape construction [48]. Low-carbon-friendly town construction methods include advanced road transportation systems, water environment ecosystems, green building energy systems, and resource utilization [49]. The research on the rural low-carbon community includes evaluating the degree of low-carbon reformations by constructing the index system for planning and layout [50], road and transportation, residential design, and environmental engineering. Low-carbon energy reform leads to the development of rural low-carbon industry [51]. Research on rural low-carbon residential technologies in different climatic areas is in-depth, such as research on key technology systems of rural low-carbon construction in cold winters and hot summers [52] as well as research on the technology systems and implementation pathways of rural distributed photovoltaics in areas with rich solar energy resources [53]. In addition, farmers’ low-carbon production decisions directly affect the carbon emission reduction and sustainable development of agriculture [54]. Research shows that farmers’ willingness to participate in low-carbon agriculture is often affected by income levels and the technical difficulties of agricultural production [55].

### 4.2. Research on Rural Green Development

#### 4.2.1. Origin, Evolution, and Connotation of Rural Green Development

In August 2005, Comrade Xi Jinping first proposed the “two-mountain theory” during his visit to Yucun in Anji County, Zhejiang Province, advocating the green transformation of traditional economic development modes. The 2018 Central Rural Work Conference introduced the road to green development in rural areas. Rural green development has

a relatively complete conceptual connotation and theoretical framework. Its scientific connotation lies in achieving sustainable resource use, green agricultural development, urban–rural relationship coordination, rural living environment reconstruction, and local complexes [24]. As an important component of rural green development, sustainable green agricultural development has far-reaching significance [56]. Green agricultural development is a mode relative to the cost of excessive consumption and environmental damage [57]. It takes resource environment carrying capacity, resource utilization efficiency, and ecological conservation as fundamental requirements, environmental friendliness as an intrinsic property, and green product supply as the important goal [17]. Based on the system deconstruction and construction perspective, agricultural green development systems include three subsystems (i.e., agricultural production, agricultural ecology, and social and economic systems), as well as coordination, correlation coupling, ecological threshold, and sustainable development theory support systems [17]. In addition, the theoretical research of rural green development has high permeability and guidance. The organic combination of rural green development and rural poverty governance forms the green poverty reduction theory [58].

#### 4.2.2. Research on Green Development of Rural Industry

First, research on green agriculture development modes, industrial clusters, innovation and entrepreneurship, agricultural green transformation and development, and agricultural green development measurement have emerged [15,59,60]. Second, agricultural green development research focuses on rural industries' green development, mainly including green development measurement, agricultural green production efficiency, constraint factors, development countermeasures, and realization pathways. The findings of the evaluation of agricultural green development levels in Chinese provinces show that China's agricultural green development levels vary greatly. The growth of agricultural output value in eastern regions is significantly higher than that of central, western, and northeast regions [60]. According to the research conclusion of the comprehensive evaluation of green agricultural development in Zhejiang Province from 2002 to 2016, the comprehensive utilization index of green agricultural resources showed a fluctuating upward trend and regular changes in different development stages [21]. The research on the implementation pathways of green development of rural industries includes large-scale operations, construction of green agricultural industry chains, and improvement of socialized service levels of green agricultural production [61]. Third, from a micro perspective, individual farmers and new business entities are chosen as the research objects to study their green production willingness and behavior-influencing factors. The research shows that general value, cost risk, government incentives, sales prospects, and environmental value are relevant factors affecting farmers' green production [62]. The transformation of green production of new business entities can be guided by cultivating a market environment, reducing endowment constraints based on economic guidance, and adhering to classified policies [63].

#### 4.2.3. Research on Rural Green Transformation and Development

The research types include different regional modes (such as water towns and mountainous areas) and different location modes [64] (such as economically developed areas and suburban integration areas). The ecological mulberry-based fish pond mode in water towns is one way to promote green transformation [65]. The green development in mountainous areas has formed specific countermeasures to four systems: green livability, green industry, green support systems, and green governance [66]. The research content includes overall rural transformation, green transformation of rural micro and small enterprises and industries, and rural green infrastructure. The evaluation research of rural green development is mainly based on quantitative research, showing the increasing efficiency of rural green development in China. However, there are certain interprovincial differences: green development efficiency in economically underdeveloped areas is higher than in economically developed areas; the efficiency in coastal areas is higher than inland areas [67]. In terms of



the evaluation system of rural green development, some studies have constructed the index system of rural green development in China from three dimensions: rural ecological environment quality, intensive and efficient rural production, and a healthy and livable rural living environment. The conclusion shows regional differences and spatial agglomeration characteristics in China's rural green development level [20].

#### 4.3. Research on Green and Low-Carbon Integrated Rural Development

##### 4.3.1. Formation of the Concept of Green and Low-Carbon Rural Development

The broad concept of green development focuses on ecology and low-carbon fields. It forms the overall concept and practice system of GLRD. In 2021, the Guiding Opinions of The State Council on Accelerating the Establishment and Improvement of the Economic System for Green, Low-Carbon, and Circular Development proposed to establish and improve an economic system for green, low-carbon, and circular development. The Law of the Promotion of the People's Republic of China in 2021 proposed to promote the reduction of agricultural inputs, cleaner production, and industrial ecological modes to guide rural society to form green and low-carbon modes of production, life, and consumption. The introduction of various important policies, measures and construction standards, such as the Evaluation Index for Green and Low-Carbon Key Small Towns (Trial) (2011), Guidelines for Low-Carbon Community Pilot Construction (2015), and Opinions on Strengthening Green and Low-Carbon Construction in Counties (2021), marks the gradual formation of the concept of GLRD.

##### 4.3.2. Research on Green–Low-Carbon Integrated Development in Rural Areas

First, “green” and “low carbon” are more integrated in terms of technical systems. Taking the study on green agriculture and green agricultural development as an example, low-carbon production conditions are important indicators of the comprehensive evaluation of green agriculture. The specific indicators include carbon emissions from agricultural production activities and material utilization, N<sub>2</sub>O emissions caused in the crop planting process, and CH<sub>4</sub> emissions produced in rice fields [68]. The agricultural green development technology system includes promoting biopesticide and degradable film production technology and constructing a low-carbon circular ecological agricultural production system. Second, driving rural and agricultural green transformation using low carbon has become a possible way of reducing carbon emissions [13]. Green and low-carbon coordinated development is transforming into new urbanization [69]. Third, GLRD also has interactions. For example, excessive agricultural carbon emissions are mainly responsible for the low efficiency of agricultural ecology. Strengthening agricultural carbon emission control is an important way to improve agricultural ecological efficiency [70].

##### 4.3.3. Policy Research on Green and Low-Carbon Rural Development

Foreign experience and research mainly include three directions. The first direction involves the experiences of other developed Asian countries, such as Japan's agricultural development policy of building a value chain through agricultural cooperatives and regulating greenhouse gas emissions through differentiated regional budget distribution policies [71,72]. The second is focused on the GLRD transformation experience and policies of developed agricultural countries or regions in Europe, such as the Netherlands, Germany, and Israel. Their experience includes: (1) a sustainable development mode, strict agricultural resources, and environment supervision systems (water management) and government support systems in the Netherlands [73,74]; (2) focusing on the improvement of a protection mechanism for farmers' interests in the EU Common Agricultural Policy [75]; (3) efficient use of water and soil resources embodied in the management policies, utilization efficiency priorities, efficient use of innovative resources, and public participation and publicity in Israel [76]. The third direction involves advanced management GLRD policies in the United States, such as the carbon pricing policy [77] and low-energy building verification policy [78]. Meanwhile, the United States has also formed a low-carbon agricultural

policy system, including specific topics such as soil conservation and tillage, agricultural carbon energy, and agricultural carbon trading. China's rural green development policies are constantly evolving and improving [79], and they have limitations of unbalanced policy tool structures and a low coordination of policy subjects [80]. There are more policy recommendations on green and inclusive finance [81], whereas relatively few studies were conducted on land use and space control policies that address actual GLRD needs.

## 5. Research Trends in GLRD in China

In general, the research on GLRD in China has the following characteristics. First, the research content is gradually enriched. The research on rural low-carbon development and green development not only includes efficiency evaluation, evolution and drive, technology system, development policy and other research dimensions but also covers multiple research levels (theory, practice and trend) and research objects (agricultural industry, rural living environment, rural communities and farmers). Second, the research focus is becoming increasingly prominent. The research on green and low-carbon development of the rural industry is the most important research content and always runs through all levels of rural green and low-carbon research. The research content of green and low-carbon development in rural industries mainly covers agricultural transformation, micro and small rural enterprises, rural tourism, rural industrial chain and rural green agricultural products. Third, research integration gradually gets strengthened. Low-carbon and green development research is the continuation and transformation of ecological and sustainable development research. From one-way research to green and low-carbon integrated research, it is mainly reflected in the scientific connotation, overall goal, technical system and other aspects.

However, there are still some limitations. First, measurement standards are non-unified. It is difficult to unify the measurement standards of carbon emissions, carbon sink income and green development in rural areas. It is necessary to study rural green development, green agricultural development and various evaluation index systems. For example, the green agricultural development evaluation index system can be established from the three dimensions of water resource utilization, environmental pollution and quality and growth quality [82]. Second, the research depth should be strengthened. Existing studies are mainly conducted on national, provincial and other large regional scales, whereas there are few micro studies on small regional scales and farmers at the county (city) level. There are many quantitative studies on agricultural carbon emission measurement and low-carbon level evaluation, whereas relatively few systematic studies on GLRD technologies are available. This led to a lack of targeted green and low-carbon technologies and microemission reduction measures. The research focuses on green and low-carbon rural production with less attention to green and low-carbon rural life. Third, policy research is relatively weak. It mainly focuses on agricultural green and low-carbon development policy, and the overall policy research content of GLRD is relatively weak.

The research should be strengthened in the following aspects. First, the scientific evaluation of green and low-carbon rural functions should be strengthened. Due to the operational contradictions between agricultural economic growth and carbon emission decoupling, the scientific evaluation research of rural green and low-carbon functions is particularly important. We should further strengthen the data collection and statistical research of rural green ecological resources and green and low-carbon evaluation, identification, and potential assessment research. Second, the development pathways of green and low-carbon rural industries should be studied in depth. Green and low-carbon development of rural industries is still the key. Other countries have taken green development modes and carbon emission reduction as important measures to deal with climate change [83,84]. Some experience has been obtained in terms of the measures to reduce agricultural carbon emissions, including improving agricultural planting technology by changing the crop density of crops and reducing the absolute practical amount by improving the efficiency of nitrogen fertilizers. These measures can effectively reduce agricultural carbon emissions [85,86]. In terms of

strengthening agricultural carbon emission management, the carbon tax can feed farmers and change their consumption habits to a certain extent, thus facilitating reducing agricultural carbon emissions. Afforestation and strengthening the sustainable use of biofuels can also reduce agricultural carbon emissions [87]. It is necessary to further deepen the research on the development pathways of green and low-carbon rural industries in technology, organization, and operation. The research should be expanded from microresearch perspectives of farmers, agricultural enterprises, and new agricultural business entities so as to provide specific countermeasures for the green and low-carbon transformation of China's rural industries. Third, the typical characteristic GLRD mode should be studied in depth. Relative to the rise of green rural construction modes, rural green tourism development modes, and rural capital-led development modes worldwide [88], the current China-only traditional village tourism green development mode and a small number of related studies should be expanded to different regional environments, locations, industries, and operation management systems under the typical mode of rural green and low-carbon transformation research. Finally, we should innovate GLRD policies. The legal guarantee should be strengthened by regional cooperation, compensation, and comprehensive governance mechanisms. The policies and laws in key areas should be improved. The supervision and feedback mechanisms should be established under diversified cogovernance. The incentive system suitable for multiple subjects should be improved to provide a demonstration of the smooth realization of the "dual-carbon" goal in rural areas [89]. Guided by green and low-carbon development, the compensation system should be innovated for green and low-carbon development in agriculture and rural areas. The types and contents of compensation for GLRD should be systematically divided [90]. We should also establish a comprehensive rural management mechanism, strengthen the protection and restoration of rural green ecological environments, and realize the coordinated development of rural economy and social ecology in institutional design.

## 6. Conclusions

As an ancient country with a long history of agrarian civilization, China's rural production and life contain profound low-carbon and green wisdom and ideas. At present, the "dual-carbon" goal that China is promoting is an important measure to build a community with a shared future for humans. It is significant for the sustainable development of the human economy and society. China's vast rural area plays an important role in achieving "carbon peaking" and "carbon neutrality". Therefore, rural green and low-carbon research have become hot topics in Chinese academic research. Therefore, this paper used CiteSpace to analyze 1154 Chinese core journal articles and combined quantitative analysis and qualitative summary research to comprehensively analyze the knowledge system of rural green and low-carbon research in China. The following research conclusions were achieved.

First, quantitative analysis was conducted to summarize the commonality of keywords in the GLRD research field, its staged research characteristics, and its research background as well as the evolution of the three research stages in detail. The high-frequency keywords (such as "low carbon agriculture", "carbon emission", "influence factors" and "rural revitalization") reflect that the research on GLRD focuses on agricultural industry development, has clear research objectives, and focuses on studying impact mechanisms. The research scope gradually evolves from narrow to wide and from local areas to macroscopic and overall areas. The carbon sink function of ecosystems in rural areas with a special geographic environment has been given attention. The research methods used gradually evolved from survey to quantitative analysis (such as model analysis, global ML index, and spatial analysis). Second, the qualitative summary research was conducted from three aspects (rural low-carbon development, rural green development, and green-low-carbon integrated development). The research was implemented into specific contents (such as connotation requirements, overall development and transformation of agricultural and rural industries, green and low-carbon rural construction measures, and green and low-carbon policies). It is also clear that rural low-carbon development, rural green development, and green-

low-carbon integrated development directly reflect the evolutionary results of a series of development policies in China. The green and low-carbon agricultural development mode, technological innovation for agricultural production, and the production mode transformation promote overall rural transformation. Green and low-carbon construction measures in villages and towns, residential construction, rural tourism, and related infrastructure have been studied to a large extent. China's rural green development policies are constantly evolving and improving and have been focusing on GLRD policies in developed regions. Land use and spatial control policies for actual GLRD needs are expected to become the next important research topic.

The description of GLRD research in China in this paper mainly analyzes and summarizes the stages, processes, and frontiers of GLRD research while also reviewing the research shortcomings and presenting the research outlook. This study better follows the requirements of the literature research review style and writing standards. In addition, this study collates several research contents, such as the connotation, development modes, development evaluation, and development policy of GLRD. This is expected to provide relevant ideas for China and other developing or developed countries to build a green and low-carbon urban–rural community. In addition, this study will provide some references for studying rural geography, economics, and ecology and may extend current research to broader special research fields. However, this study has some limitations because the research data are mainly from Chinese CSSCI and CSCD databases. The representativeness of the research literature may be lacking. The research contents that should be focused on may not be in-depth enough. The GLRD research should be a research topic with practical guidance. Despite these limitations, this study has more theoretical significance than practical significance. It is necessary to combine specific GLRD practices as much as possible to form more valuable research content in further research.

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