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Review

A Review of Agricultural Land Functions: Analysis and Visualization Based on Bibliometrics

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Abstract: Achieving the goals of global food security and sustainable agricultural land use requires research that understands the processes and mechanisms of change in agricultural land systems. Agricultural land function is a suitable research area. Therefore, this paper collected 1643 papers on agricultural land function from the Web of Science Core Collection as research materials. HistCite, CiteSpace, and VOSviewer were used as the bibliometrics analysis tools to study basic information, research progress, hotspots, and frontiers in agricultural land function. The results showed that over the past 30 years, publications on agricultural land function have increased, and the dominant authors and institutions were located in the United States, China, Europe, etc. Land use, agriculture, and multifunctionality were research hotspots in this field. The research frontier included the interaction analysis between land use pattern and function, the evaluation and valuation of agricultural land function, the interaction and driving factors between agricultural land functions, and the relationship between agricultural land function and sustainability. This study could help researchers further understand the research status on agricultural land function, playing a fundamental role in the sustainable utilization of the agricultural land system and the realization of global food security goals.

Keywords: agricultural land system; bibliometric analysis; Web of Science; research hotspots

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1. Introduction

The land system results from the interaction of humans and the natural environment [1]. Through adaptation and mitigation, land systems provide solutions to global change and sustainable development goals [2]. As a combination of the agricultural system and land system, the agricultural land system is an agricultural system with land as the core, including all the activities and results of humans using agricultural land [3]. Moreover, the agricultural land system is also a dynamic and complex social system whose core function is to ensure human livelihood and food security [4]. However, extreme weather, the COVID-19 pandemic, regional conflicts, and the rising cost of food and fuel threaten global food security and the sustainable use of the agricultural land system [5]. The agricultural land system is a core research area of global environmental change and sustainable development, which plays a critical role in realizing the Sustainable Development Goals (SDGs) [6]. Therefore, there is an urgent need to understand the processes and mechanisms of agricultural land system change to provide a research basis for global change, food security, and sustainable agricultural development.

Compared with land systems research [7,8], the research on agricultural land systems is still relatively backward [4]. The research on the agricultural land system should refer to the paradigms and progress of land system research. Some studies have shown that the focus of land system research has gradually developed to land function from early land use and land cover and their temporal and spatial changes [9]. The land function has gradually become a hot spot in land systems and sustainable land use [10–12]. The ability of the land to provide goods and services is called land functions (LFs) [9,13,14], also known as land system functions or land use functions [15]. In contrast to the land system structure, function emphasis is much more on the recessive attributes of the land system [16,17]. The analysis of land function can fully understand the internal interaction of land systems and further improve the cognition and characterization of land change [9]. Therefore, this study systematically reviews the research on agricultural land function from the perspective of function.

The agricultural land system provides the largest share of the food supply, which is the most critical function of agricultural land [4]. Moreover, agricultural land functions encompass not only the provision of goods and services related to the intended land use (e.g., food and timber production) but also goods and services often unintentionally provided by land, such as aesthetics, cultural heritage, and biodiversity conservation [18]. Although agricultural land's primary role is to produce food and fiber, land conservation, maintenance of landscape structures, sustainable management of natural resources, biodiversity conservation, and contribution to the socio-economic vitality of rural areas are also important [19]. Farmlands, not just forests and wetlands, help regulate urban climate [20] and carbon sequestration [21]. In terms of a single function, agricultural land is inferior to built-up land. Still, in terms of economic, ecological, and cultural comprehensive functions, the general advantage of the agricultural land system is very prominent [22]. The agricultural land function in this study is the goods and services provided by the natural environment and human activities on the agricultural land system, including environmental, economic, and social dimensions.

A series of terms, such as multifunctionality of agriculture (MFA) [23], ecosystem function and service [23], and landscape functions [13], was often confused with agricultural land functions (ALFs) and needed to be distinguished. MFA has been recognized by the FAO, EU, and OECD [19]. Its connotation extends from the scope of world trade protectionism to agricultural policy instruments, which is a vital concept in the research and decision making of sustainable agriculture [23]. Ecosystem functions and services, landscape functions, and ALFs are all aimed at realizing the sustainable use of land [24]. Among them, ecosystem function is the capacity of natural processes and components directly or indirectly to provide goods and services that satisfy human needs [25], which covers the internal functions of ecosystems (e.g., maintenance of energy fluxes, nutrient (re) cycling, food web interactions) as well as the benefits that humans derive from ecosystem characteristics and processes (e.g., food production and waste disposal) [26]. Ecosystem service refers to the ability of ecological processes and components to directly or indirectly meet human needs. It focuses on the contribution and value of the ecosystem to human welfare and exists because of human needs [27]. Landscape function refers to the interaction between landscape structure and ecological processes [28], and it is generally regarded as the joint supply of multiple ecosystem services at the landscape level [29].

The connotation of ALFs is different from landscape function, ecosystem function, and service. The ALFs cover a more extensive scale than the landscape function, which can be regional or global, while landscape refers to a specific scale. The landscape function is essentially inclined to (semi-)natural pillars, while ALFs mainly focus on human needs and coordinate with nature [30] to assess the direct impact of land use change on the economic, social, and environmental dimensions of sustainability [31]. Ecosystem services (ESs) regard the ecosystem as the basis of human well-being [24], while the essential object of ALFs is the (agricultural) land system. In addition, ALFs have more connotations than ecosystem function and service, involving economic and social functions [15]. For example, in artificial ecosystems (such as farmland systems), ESs are limited to those provided by natural capital [32,33], while ALFs represent connotations related to the economic, social, and environmental domains, which are broader than ESs [34].

To sum up, agricultural land functions are an excellent perspective to analyze the agricultural land system. In the context of global food security and sustainability of agricultural land, it is vital to study the agricultural land system and its function [3]. An agroecosystem is an artificial and natural compound ecosystem that usually provides certain ecosystem services and functions more effectively on a small spatial scale and a limited period [35]. Different from general land functions, agricultural land functions have obvious spatial and temporal limitations and variability [35], which should be studied separately. To understand the research progress of agricultural land functions, this paper takes the broad agricultural land (including arable land, woodland, grassland, and aquaculture surface) as objects, analyzing the research progress of agricultural land function with the bibliometric method. Firstly, the papers on themes of agricultural land function published between 1991 and 2021 were collected in the Web of Science Core Collection. Secondly, the bibliometric analysis tools of HistCite, CiteSpace, and VOSviewer were used to analyze the basic information, research progress, research hotspots, and research frontiers of agricultural land function. Finally, the main research frontiers were analyzed in the discussion. The paper could provide a reference for researchers of agricultural land function.

2. Materials and Methods

2.1. Data Source

The data were collected from the Web of Science Core Collection, which contains vital literature data from around the world [36]. The data retrieval strategy was to search papers on agricultural land function published between 1991 and 2021 by subject terms in the first place. Then, the articles were screened and examined with refined tools in the research direction of forestry, agricultural policy, remote sensing, sustainability science, human geography, and environmental sciences. Finally, 1643 publications about agricultural land function from a total of 5165 publications were obtained as research material in this paper.

Specifically, the subject terms included: agricultural land system functions, agricultural land (use) functions, multifunction arable land use, multifunction cultivated land, multifunction farmland, and multifunctionality of agriculture land use. The reason for choosing these terms is that the agricultural land function in this study includes the functions covered by all agricultural land (cultivated land, woodland, grassland, and pond surface). The study highlighted the function of cultivated land, and cultivated land, arable land, and farmland were used as synonyms for replacement. It was believed that multifunction was also a part of functional research. Therefore, the retrieval operators were all concatenated with “or”. In addition, it is worth noting that all search titles do not use quotation marks (“”), meaning that the search engine will retrieve records containing all the words entered, which may or may not appear together.

2.2. Methods

The bibliometrics analysis method uses statistical mathematics to conduct quantitative analysis, description, and visualization of the literature in related research fields. It can investigate the current situation and predict future research trends and hot spots [36]. Plenty of bibliometrics software exists, such as HistCite, CiteSpace, VOSViewer, and so on [37]. Each type of software has different advantages.

In this study, HistCite Pro 2.1, CiteSpace [38], and VOSviewer 1.6.18 [39] were used to analyze the papers on the function of agricultural land screened above. Among them, HistCite Pro 2.1 was used to analyze the classic literature and major journals on agricultural land function. CiteSpace was used to analyze the authors, institutions, countries, and keywords. VOSviewer 1.6.18 was used to analyze the research topics and progress. The main literature was analyzed in HistCite Pro 2.1 software using Graph maker, selected by LCS, limit 20; the analysis of journals used analysis tools in HistCite Pro 2.1. In CiteSpace software, author, institution, and country were selected, respectively, for visualization analysis. The selection criteria were selecting the top 30 levels of most cited or occurring items from each slice and pruning them by pruning sliced networks and minimum spanning trees. Regarding keyword clustering, the recommended LLR method was selected to optimize the clustering. Furthermore, the keywords co-occurrence analysis was set to analyze the research topic in VOSviewer 1.6.18 software. In addition, statistical analysis of other data was carried out in Microsoft Excel.

3. Results

3.1. Basic Information on Agricultural Land Function Research

3.1.1. Classical Papers

In HistCite Pro 2.1 software, the Local Citation Score (LCS) is the number of citations of certain documents in its research field. The higher the LCS, the more classic and authoritative the paper is in the research field. The Global Citation Score (GCS) is the number of references to some documents in the integrated WOS database. The higher the GCS, the higher and broader the acceptability of the literature, which may be a review article to a large extent. These two indicators are useful, especially for researchers new to the field of agricultural land function, who can quickly understand the area by reading literature with a high LCS and GCS.

LCS was used to screen out the 10 kinds of literature most cited by peers in the field of agricultural land function (Table 1). It can be seen from Table 1 that the papers about multifunctional land use and multifunctional agriculture from Wiggering et al. [14], Renting et al. [40], and Zasada [41] were highly recognized by peers in agricultural land function communities. The LCS values were all 29. Meanwhile, a paper on global agroecological intensification, biodiversity function, and food security [42] also had the highest GCS value, exceeding one thousand.

Table 1. The top 10 LCS papers in terms of agricultural land function.

NO.	Title	LCS	GCS	References
1	Indicators for multifunctional land use—Linking socio-economic requirements with landscape potentials	29	168	[14]
2	Exploring multifunctional agriculture. A review of conceptual approaches and prospects for an integrative transitional framework	29	290	[40]
3	Multifunctional peri-urban agriculture-A review of societal demands and the provision of goods and services by farming	29	383	[41]
4	Functional and phylogenetic diversity as predictors of biodiversity- ecosystem-function relationships	28	726	[43]
5	Global food security, biodiversity conservation and the future of agricultural intensification	26	1073	[42]
6	Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits	24	467	[44]
7	Land use intensification alters ecosystem multifunctionality via loss of biodiversity and changes to functional composition	24	379	[45]
8	From land cover change to land function dynamics: A major challenge to improve land characterization	23	351	[9]
9	Exploring multi-scale tradeoffs between nature conservation, agricultural profits and landscape quality-A methodology to support discussions on land-use perspectives	20	136	[46]
10	Biodiversity and ecosystem services in agricultural landscapes—Are we asking the right questions?	18	411	[47]

3.1.2. Leading Authors, Institutions, and Countries

According to the number of published papers from authors, authors with more than or equal to seven publications in the field of agricultural land function were screened out. The research institutions, countries, and citations are shown in Table 2. As can be seen from Table 2, there were sixteen authors with seven or more published papers. Among them, Tscharntke T was the author with the highest number of publications in this field, had published sixteen relevant articles in total, and his LCS and GCS were the highest. Verburg PH followed with 12 papers.

Table 2. Authors with more than seven publications on agricultural land function.

NO.	Author	Institution	Country	Counts	LCS	GCS
1	Tscharntke T	University of Göttingen	Germany	16	63	2774
2	Verburg PH	VU University Amsterdam	Netherland	12	49	928
3	Clough Y	University of Göttingen	Germany	8	32	1702
4	Holzel N	Münster University	Germany	8	33	721
5	Lindborg R	Stockholm University	Sweden	8	13	390
6	Long HL	Chinese Academy of Sciences	China	8	21	542
7	Rossing WAH	Wageningen University and Research Centre	Netherland	8	69	652
8	Wang H	Jiujiang University	China	8	9	129
9	Wang YH	Northwest A&F University	China	8	0	98
10	Fischer M	Senckenberg Biodiversity and Climate Research Centre	Germany	7	32	745
11	Groot JCJ	University of Bern	Switzerland	7	67	611
12	Lavorel S	Wageningen University and Research Centre	Netherland	7	20	622
13	Marull J	Universite' Joseph Fourier	France	7	15	121
14	Paruelo JM	Autonomous University of Barcelona	Spain	7	12	272
15	Tello E	Universidad de Buenos Aires	Argentina	7	15	117
16	van Noordwijk M	University of Barcelona	Spain	7	19	548

Citespace 6.1.R3 software was used to carry out the co-occurrence visual knowledge map of authors with many publications, as shown in Figure 1. Each node is on behalf of an author, and the connections between authors form varying sizes of clusters [36]. The cluster density represents the authors' contact and cooperation [48].

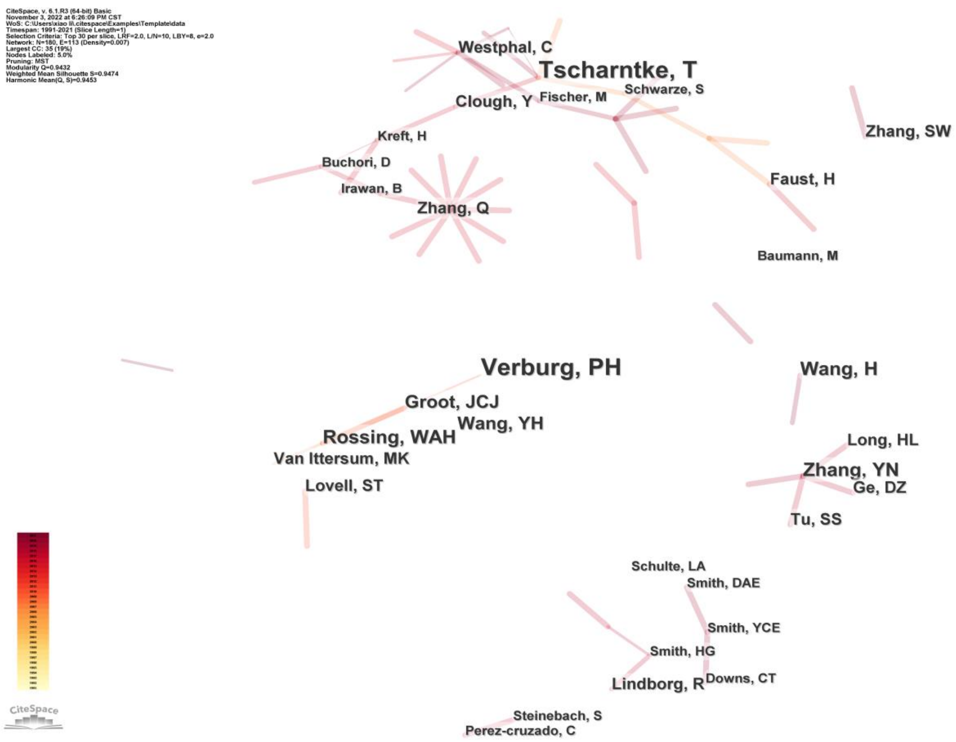

Figure 1. Co-occurrence network of top 30 authors with publications (the legend represents the color display for each year from 1991 to 2021).

According to the cooperative relationship, researchers addressed four major clusters. The first was based on Tscharntke T, including Clough Y, Fischer M, Kreft H, Westphal C, and other cooperative clusterings. Most of them came from German universities and research institutes. The second was well represented by Verburg PH, including the cooperative clustering of Rossing WAH, Groot JCJ, and van Ittersum MK. They were mainly from universities and institutes in the Netherlands and Switzerland. The third was Chinese Academy of Sciences researchers, including Long HL, Ge DZ, Tu SS, and Zhang YN. The fourth cluster included Schulte LA from the United States and Lindborg R from Sweden, but their cooperation could have been more obvious. Generally speaking, collaboration among agricultural land function researchers is mainly within the same institution or country. There is a need for more cooperation between researchers and institutions from different countries.

The visual knowledge map of the research institution used Citespace 6.1.R3 software (Figure 2). The node represents the number of publications of institutions in Figure 2. The larger the node, the more publications it has. Therefore, institutions with a large number of publications in the field of agricultural land function include Chinese Acad Sci, Univ Chinese Acad Sci, Univ Gottingen, Wageningen Univ, INRA, Univ Copenhagen, Swedish Univ Agr Sci, UFZ Helmholtz Ctr Environm Res, Humboldt Univ, and Beijing Normal Univ. According to the statistical results, between 1991 and 2021, these institutions published 77, 36, 34, 33, 32, 30, 24, 21, 19, and 18 papers, respectively. The red nodes represent the citation bursts of institutions, that is, the institutions with the highest citation bursts are INRA, Univ Wageningen & Res Ctr, and AgroParisTech, whose outbreak periods are 2005–2014, 2005–2012, and 2009–2016, respectively.

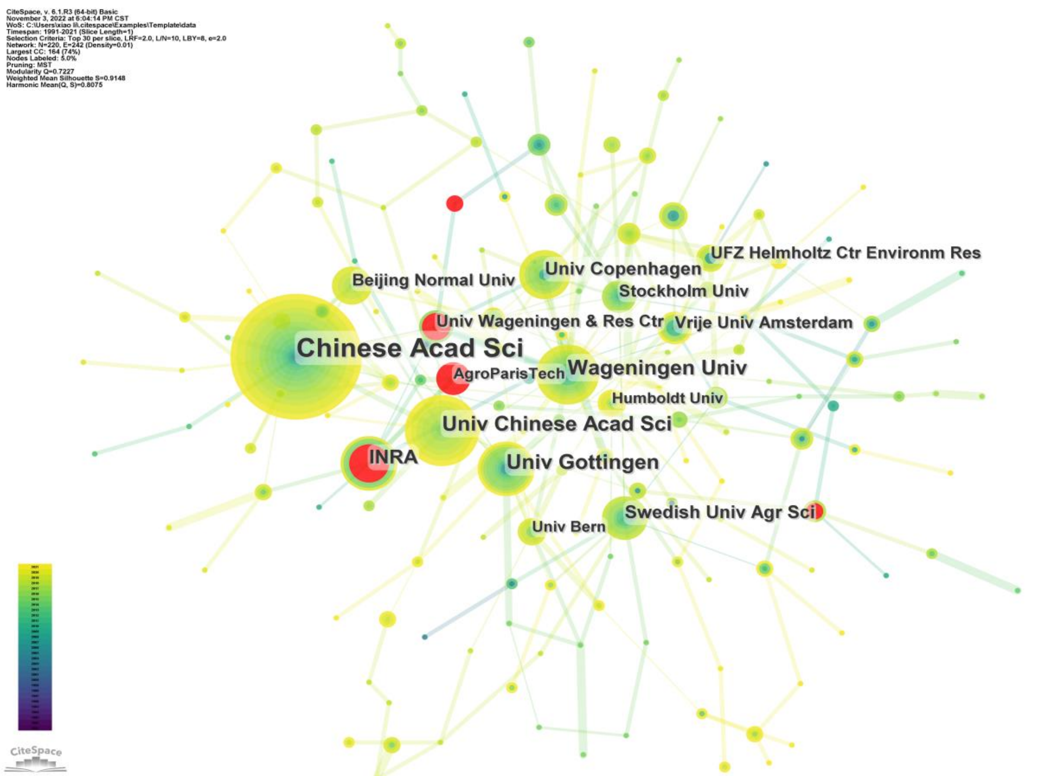

Figure 2. Co-occurrence networks of the top 30 institutions with publications (the legend represents the color display for each year from 1991 to 2021).

EXCEL was used for statistical analysis of countries with many publications (Figure 3). As can be seen from Figure 3, the major countries that study agricultural land function were the USA, China, Germany, the UK, France, Australia, Netherlands, Spain, Italy, and Switzerland. They all recorded more than 60 papers during 1991–2021, with the US at the highest (348) and Switzerland at the lowest (68). The USA had the largest amount of published papers and citations, far exceeding other countries. China ranked second in the number of publications, while the citation rate was relatively low. Germany and the UK had the second- and third-most-cited papers, respectively.

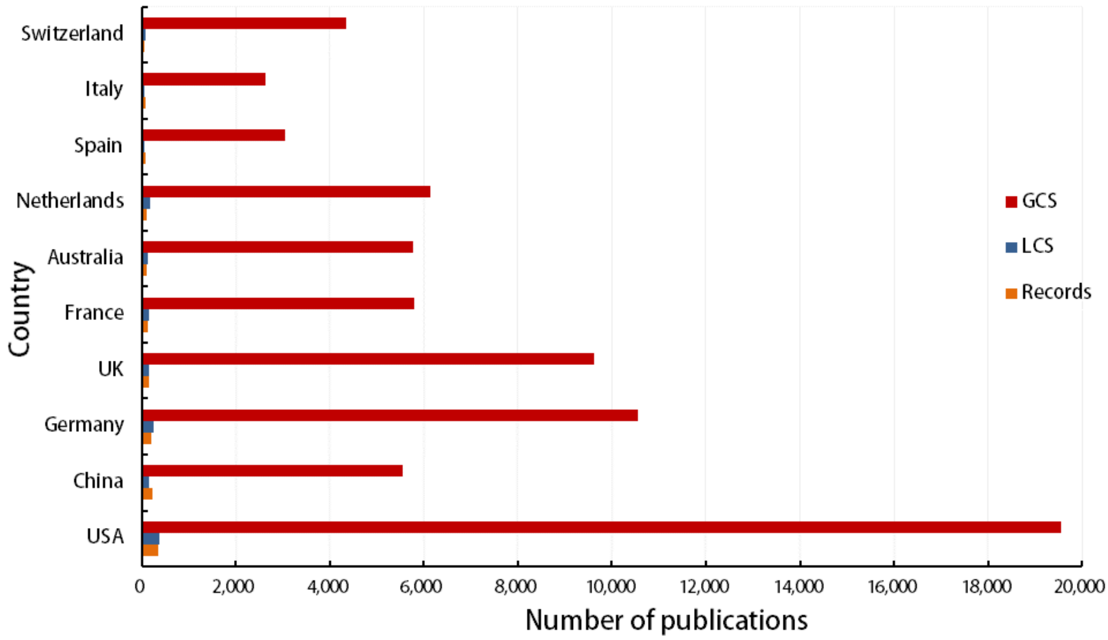

Figure 3. Top 10 countries with publications on agricultural land function.

3.1.3. Major Published Journals

Table 3 lists the top 15 most productive journals about the agricultural land function between 1991 and 2021. *Land Use Policy* was the most productive journal, publishing 81 papers in this field, followed by *Agriculture Ecosystems Environment* with 52 publications. In addition, *Sustainability, Ecological Indicators*, and *Landscape and Urban Planning* published over 30 articles. Regarding the number of journal citations, the LCS and GCS of *Agriculture Ecosystems* and *Environment* were the highest, and *Land Use Policy* was the second. These two journals were the core journals of agricultural land function research. On the contrary, the LCS of *Sustainability* and *Land* was 0, meaning the quality of the articles on agricultural land function in these journals needs to be improved.

Table 3. Top 15 journals and their co-citations on the topic of agricultural land function.

NO.	Name of Journal	Counts	LCS	GCS
1	*Land Use Policy*	81	118	3679
2	*Agriculture, Ecosystems & Environment*	52	139	3952
3	*Sustainability*	48	0	385
4	*Ecological Indicators*	35	83	1683
5	*Landscape and Urban Planning*	31	26	1285
6	*Journal of Environmental Management*	29	92	1649
7	*Remote Sensing*	29	3	678
8	*Forest Ecology and Management*	27	7	955
9	*Agricultural Systems*	26	30	1047
10	*Biological Conservation*	25	78	2914
11	*Journal of Applied Ecology*	25	38	1581
12	*Land*	22	0	183
13	*Landscape Ecology*	20	35	1007
14	*Remote Sensing of Environment*	20	8	1763
15	*Science of the Total Environment*	20	25	707

3.2. Research Progress of the Agricultural Land Function

Based on the statistics of works of literature related to the agricultural land function, studies from 1991 to 2021 were divided into three research stages (see Figure 4) according to the changes in published papers' numbers per year. (1) initial stage: 1991–2003, the number of published papers each year was less than 30; (2) development stage: 2004–2014, the annual number of publications ranged from 33 to 80; (3) prosperous stage: 2015–2021, the annual number of publications is more than 100.

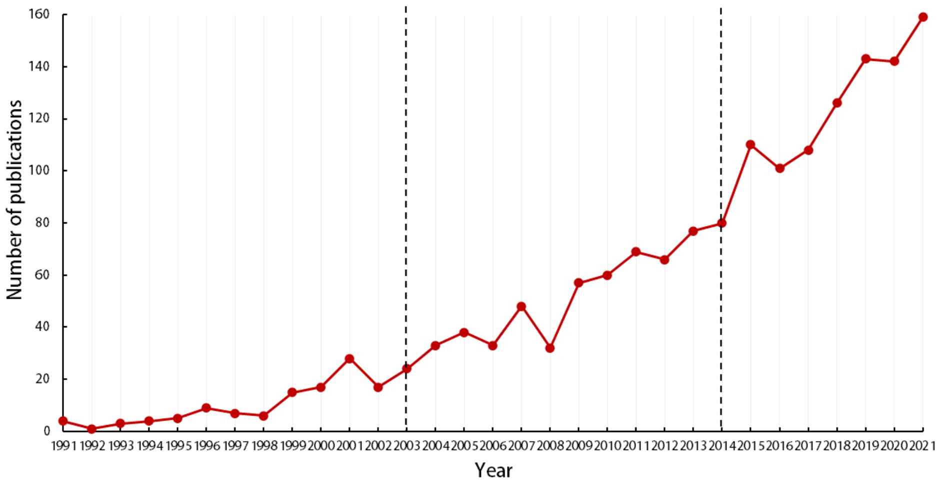

Figure 4. The annual number of publications on agricultural land function in the WOS Core Collection (1991–2021).

The research status of each stage is as follows:

Initial stage (1991–2003) (Figure 5): In this stage, papers on agricultural land function mainly included five clusters. The zeroth cluster studied agricultural production form and landscape, and the main keywords include slash-and-burn agriculture, spatial models, landscape ecology, forest fragmentation, and landscape mosaic. The first was the study of agricultural land use using remote sensing data and means, and the main keywords include NDVI, primary production, grasslands, NOAA/AVHRR, and remote sensing. The second was the study of agricultural land cover from the perspective of integrated natural resource management. Its keywords were remote sensing, land cover, integrated natural resource management, Proland, and scenarios. The third was the study of agricultural land cover and the environment by combining GIS and remote sensing. Its main keywords were land cover, environmental indicators, GIS, remote sensing, and South America. The last one was the study of agricultural land use and agricultural ecosystem, in which agricultural land use, agroecosystem health assessment, agroecosystem health, optimality, and agroecosystem were the primary keywords.

Development stage (2004–2014) (Figure 6): In this stage, eleven clusters were included in the research on agricultural land function. The zeroth cluster studied the multifunctional landscape of urban agriculture, including urban agriculture, linear programming, agroforestry, multifunctional landscape, and species richness. The first was the study of agricultural function and diversity, including species richness, diversity, edge effects, functional groups, and tropical forests. The second was the assessment of land cover and land function. It mainly focused on urban expansion and introduced a random forest regression model and other means. The third was the study on the multifunctional utilization and sustainable development of European agriculture and agricultural land represented by France. The keywords included France, multifunctionality, sustainable development, agriculture, and post-productivism. The fourth was the comprehensive assessment of the sustainable use of agricultural land, including sustainability assessment, strategic environmental assessment, integrated assessment, GIS, and cropping system. The fifth was about changes in forests and other landscapes, landscape change, landscape transformation, forest fragmentation, and organic carbon were included. The sixth was research on functional characteristics and layout of farmland for specific crops and trees, including functional traits, catastrophe theory, silver birch, crop choice decision, and reproduction. The seventh was agricultural land management, such as land erosion, hydrology, and vegetation, including erosion, eco-hydrology, vegetation, land management, and other keywords. The ninth was the agricultural land function and climate change research, including soil erosion, climate change, land function, agricultural data, etc. The tenth was the study of forest land by remote sensing, including reforestation, forests, and organic matter.

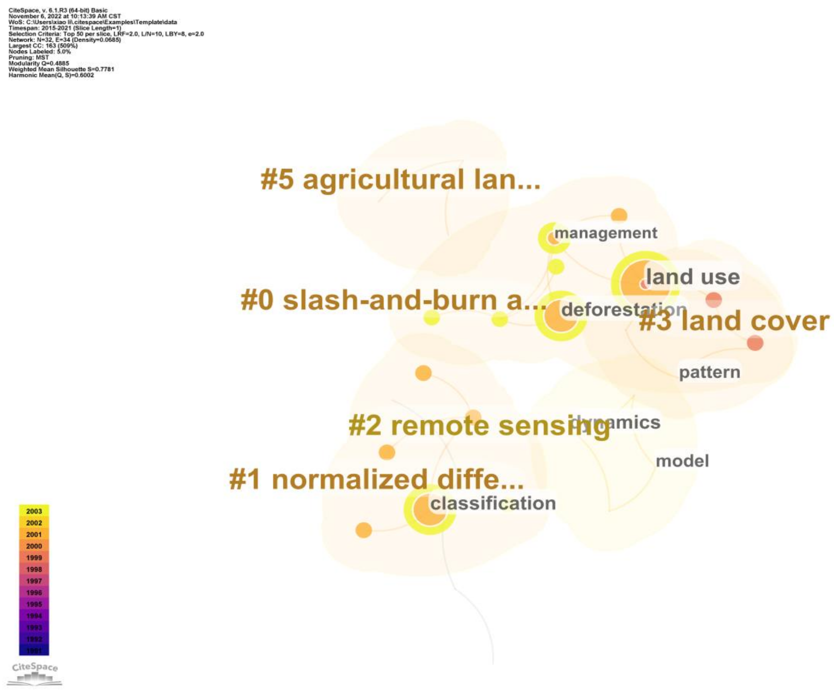

Figure 5. Cluster map of keywords of agricultural land function in the initial stage (the legend represents the color display for each year from 1991 to 2003).

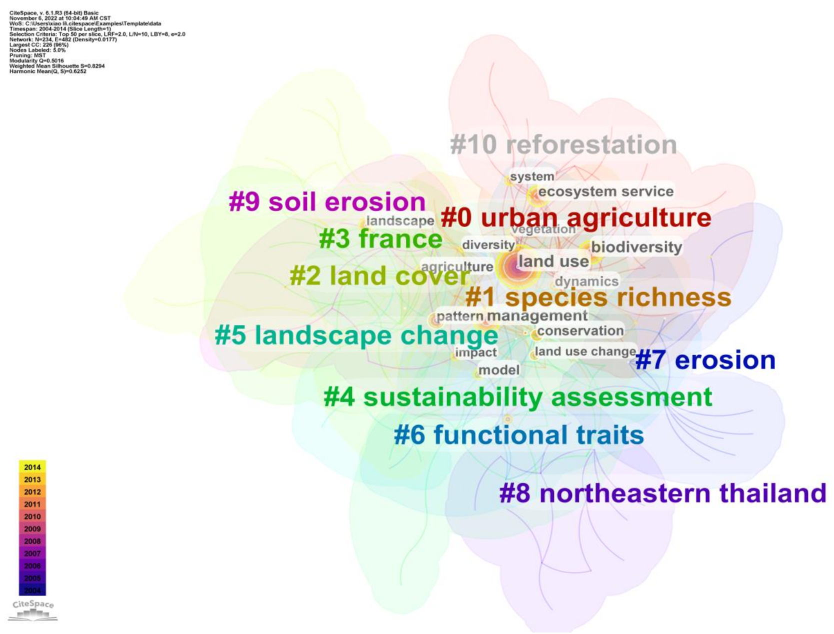

Figure 6. Cluster map of keywords of agricultural land function in the development stage (the legend represents the color display for each year from 2004 to 2014).

Prosperity stage (2015–2021) (Figure 7): There were eight clusters in the field of agricultural land functions at this stage. The zeroth cluster was the tradeoff between landscape structure utilization intensity and farmland function, including species richness, biodiversity, tradeoffs, and landscape composition. The first was the land cover and spatial analysis, with keywords of spatial statistics, land cover, China, watershed, and vegetation index. The second was the function research of urban and rural agriculture, and the main keywords were urban agriculture, urbanization, rural geography, urban and peri-urban agriculture, and urban agroecology. The third was to study the land use function of tropical forest grassland, including land use change, savanna, land, cross-border comparison, and Namibia. The fourth was the spatial analysis of the functional diversity in agricultural land and the study of climate change, including restoration, climate change, functional diversity, spatial analysis, and wetlands. The fifth cluster researched land use, including nitrogen, phosphorus, land tenure, soil organic carbon, and land sharing. The sixth was the study of land use change and function, including habitat fragmentation, cultural landscape, disturbance ecology, oil palm, and land use change. The seventh was about agricultural land productivity and farm size, including farm size, productivity, Ethiopia, insects, and credit program. The eighth was the study of the relationship between agricultural land functions, tradeoff and synergy, Southern Europe, land responsibility, farm typology, and self-identity.

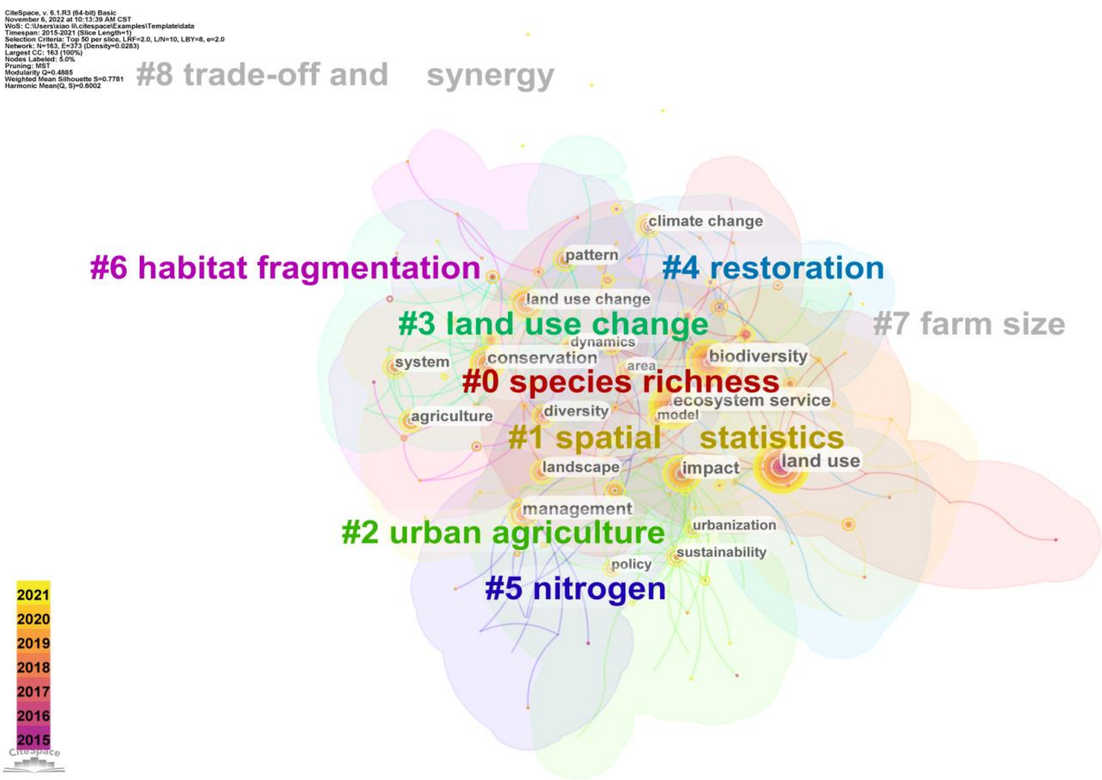

Figure 7. Cluster map of keywords of agricultural land function in the prosperity stage (the legend represents the color display for each year from 2015 to 2020).

3.3. Research Hotspots of Agricultural Land Function

Analyzing high-frequency keywords is the key to studying hot issues in a field [49]. Therefore, this study uses the influence strength of keywords in the agricultural land function research field to explain the research focus. The co-occurrence of the author's keywords was analyzed in VOSviwer (Figure 8). In the network visualization, labels (the default is a circle) represent keywords. The circle size of a keyword is determined by its weight. The higher the weight of a keyword, the larger the circle is. Lines between keywords represent links, and the more lines there are, the more keywords are associated with them [39]. The color bars reflect the average publication year of keywords.

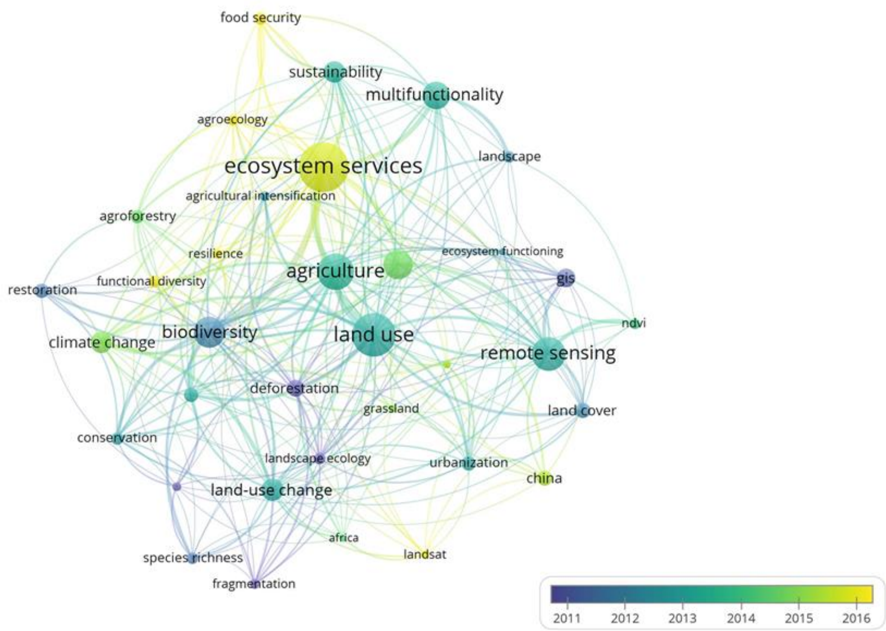

Figure 8. Network visualization of co-occurrence of author keywords in agricultural land function from 1991 to 2021 (node color is determined by the average use of each keyword).

In addition, this paper derived co-occurrence information of authors' keywords from VOSviwer (Table 4). Table 4 shows the occurrence frequency and co-occurrence frequency of the author's keywords in the study of farmland function. Among them, occurrence refers to the frequency of the keyword appearing; total link strength refers to the total number of co-occurrences of keywords and other keywords (including the number of repeated co-occurrences).

Table 4. The high occurrences of author keywords in agricultural land function from 1991 to 2021.

keyword	Occurrences	Total Link Strength	Keyword	Occurrences	Total Link Strength
ecosystem services	112	123	urbanization	24	31
land use	95	101	agroforestry	22	24
agriculture	77	89	conservation	20	41
remote sensing	70	66	food security	20	20
biodiversity	63	94	landscape	19	23
land use change	58	52	species richness	19	21
multifunctionality	55	46	functional diversity	18	20
land-use change	42	54	landscape ecology	18	32
sustainability	40	41	agroecology	17	28
climate change	39	43	ndvi	17	21
gis	33	25	agricultural intensification	16	27
deforestation	29	40	modis	16	17
China	26	15	biodiversity conservation	15	16
land cover	26	23	fragmentation	15	24
restoration	25	27	multifunctional agriculture	15	17
ecosystem function	24	46	resilience	15	21

As can be seen from Figure 8, the circles of ecosystem services, land use, agriculture, remote sensing, biodiversity, land use change, and multifunctionality are relatively large. These results indicate that their co-occurrence is relatively high, which means the focus of relevant research. In addition, the average publication year of biodiversity is 2012; land use, land use change, and remote sensing appeared around 2013; multifunctionality and agriculture appeared around 2014; and ecosystem services in 2016.

This is consistent with the popular idea that the (agricultural) land use function is closely related to the concept of agricultural multifunction and ecosystem services [31]. Research on the (agricultural) land system first focuses on land use and land cover change based on remote sensing and other means. It gradually develops into research on the function of (agricultural) land [9]. MFA community uses the term "function" or "land function" to describe the goods and services provided by land systems, which contain both the natural environment and human activities. While the ES community believes that "function" more appropriately defines an ecosystem's ability to provide services, some use the term to describe the internal functions of an ecosystem, such as energy flux and nutrient cycling, or as a synonym for "ecosystem processes" [23]. With the emergence of the concepts of ecosystem goods and services [27] and ecosystem functions [26], it has been recognized that land use change affects multiple dimensions of sustainability as a driver of other changes [31]. Agricultural systems also use land use as an essential feature, linking versatility [50].

3.4. Research Frontiers of Agricultural Land Function

Accurately identifying and tracking research frontiers in a field can reveal the latest trends and better understand the research background [36]. Words that occur more frequently in a short time are called "burst words", which are used to explain the development, emerging trends, and mutations and reflect the frontiers of field research [36]. Therefore, this paper analyzed the keywords in the field of agricultural land function from 1991 to 2021 in Citespace, including 21 emergent words, as shown in Table 5, where the 21 words were arranged from top to bottom according to the time they first appeared. The top five words with the strongest bust are dynamics, pattern, deforestation, disturbance, and urbanization, whose bust strengths are greater than five, indicating the emerging trends in the agricultural land function study.

Combining the above phase of agricultural land function (3.2), the information revealed by burst words is analyzed. In the initial stage (1991–2003), research on the dynamic change of agricultural land use patterns was quite popular, including deforestation and the growth of vegetation, etc., which all began to break out in 2001. In the development stage (2004–2014), the use of scenario simulation to analyze the responses and consequences of agricultural land functions to utilization activities attracted more attention. Many studies on human impacts, such as natural disturbance and agricultural policy, began in 2006 and 2010, respectively, and focused on grassland and tropical forest in 2007 and 2011, respectively. In addition, due to the impact of ecosystem service value [51], studies on the valuation of agricultural land functions have been mostly conducted since 2009. In the prosperity stage (2015—2021), research on the evaluation index of farmland function, the tradeoff between functions, and the driving factors of function change have received much attention. Due to the expansion of urbanization in China, which has occupied a large amount of agricultural land [52,53], studies on the impact of agricultural land function, including food safety, were quite popular around 2010.

To sum up, the research frontiers of agricultural land function include (1) analysis of the interaction between agricultural land use pattern and function; (2) agricultural land function evaluation and valuation research; (3) study of the interaction and driving factors between agricultural land functions; (4) research on the function and sustainable use of agricultural land. The research on the function of agricultural land includes cultivated land, forest, and grassland, and combines the ideas and methods of agricultural multifunctional, ecosystem services, and landscape functions. Its research frontier has changed from single agricultural land use to integrated agricultural land system management, gradually serving human needs, such as food security, climate change, and sustainable land use.

Table 5. Top 21 keywords with the strongest citation bursts.

Keywords	Strength	Year	Begin	End	1991–2021
dynamics	6.57	2001	2001	2008	
pattern	6.46	2001	2001	2008	
deforestation	5.44	2001	2001	2005	
growth	3.97	2002	2002	2007	
vegetation	4.33	2003	2003	2009	
disturbance	5.51	2006	2006	2011	
grassland	4.62	2007	2007	2012	
response	4.12	2009	2009	2015	
scenario	4.05	2009	2009	2011	
consequence	3.81	2009	2009	2011	
tropical forest	4.33	2011	2011	2017	
valuation	3.62	2009	2011	2014	
land cover	4.09	2001	2013	2016	
agricultural policy	3.76	2010	2013	2015	
driving force	4.88	2015	2015	2019	
trade off	3.87	2017	2017	2021	
indicator	3.58	2005	2017	2018	
urbanization	5.06	2011	2018	2021	
China	4.86	2010	2018	2021	
food	3.98	2013	2018	2019	
expansion	4.06	2016	2019	2021	

The blue lines in the table represent the whole research period, and the red lines represent the time when keywords are bursting.

4. Discussion

The main research directions and frontiers of the agricultural land function obtained from the bibliometric research and analysis above (3.4) are further analyzed here.

4.1. The Interaction between Agricultural Land Use Pattern and Function

The agricultural land system is a multilevel complex with a cause–effect chain of elements, structure, and function [54,55]. From the perspective of spatial combination, the pattern of the (agricultural) land system includes components and configurations [56]. Components are the quantity proportion describing the scale of land types in the land resource unit. Meanwhile, configurations are the spatial structure, which illustrates the layout form of land types in the land resource unit [57,58]. There is a corresponding relationship between land function and structure. Land use structure is the dominant form of land use, while the land use function emphasizes its recessive attribute [16,17].

(Agricultural) land use functions originate from the interweaving process of land use structure, which finally links human welfare and nature in the whole land use system [10]. It is precisely due to human demand for certain functions of land that the structure of land is changed to meet human needs. At the same time, the land use function reacts to land structure [59]. For example, when the land moves from wasteland to cultivated land, the land structure inevitably changes, and the internal land elements continue to change until a stable state is reached over time. However, the view of equating land use function with land use type/structure is not comprehensive and sufficient, and there is an urgent need to understand and model the complexity of land use function and land use type [10]. The land function is not only influenced by land cover, but many other factors may also be crucial, including the spatial arrangement and temporal intensity of land use in the landscape. The isolation of nature reserves is an example of land cover not changing but land function changing [9].

4.2. Classification and Evaluation of Agricultural Land Function

It is believed that the (agricultural) land function classification has three aspects. The first is the functional classification made by land scientists according to the characteristics of the land. For example, Liu proposed that land has four central functions: production, environment, carrier, and space [60]. Liu et al. summarized the fundamental land functions as production, bearing, providing raw materials, landscape, historical record, ecological, saving, and value-added [61]. Jiang et al. divided cultivated land functions into five categories: production, economic, ecological, social security, and cultural landscape [62].

Secondly, many researchers regard land as an ecosystem whose function is defined as an ecosystem function, with humans (potentially) as functional added value [25]. The research classifies the functions of land ecosystems into four broad categories: regulation, habitat, production, and information [26]. The Millennium Ecosystem Assessment follows this idea [18] and similar applications related to landscape [63]. Later, De Groot divided land functions into regulation, habitat, production, information, and carrier functions [13]. Fleskens et al. divided agroecosystem functions into ecological, productive, economic, social, and cultural functions [35].

In addition, with the development of multifunctional agriculture, more researchers classify (agricultural) land functions from a sustainability perspective. For example, Perez-Soba et al. used a multifunctional approach to assess the impact of land use change on its sustainable use, which covered three pillars and nine functions of sustainable use [31]. Similarly, Schoßer et al. considered six primary sectors of land use (agriculture, forestry, nature conservation, transport infrastructure, energy, tourism), direct and indirect environmental, social, and economic impacts, selected nine land use functions, including the provision of work, human health, and recreation, cultural and aesthetic values, residential and non-land-based industry and services, land-based production, infrastructure, provision of abiotic resources, support, provision of biotic resources, and maintenance of ecosystem processes [24]. Paracchini et al. represented each sustainability dimension with three land use functions: economic (residential and industrial services, land-based production, infrastructure), environmental (abiotic resources, provision of habitat, ecosystem processes), and social (work, health and recreation, culture), giving nine land use functions in all [34]. Banko and Mansberger divided land functions into three types: economic, social, and ecological. Based on summarizing the previous classification of land use function, they separated ecological function independently, highlighting the importance of land ecological function [64].

Functional assessment is a method to study the function of agroecosystems [35]. Quantitative assessment and mapping of land functions are significant for future functional tradeoffs, planning, management, and policy formulation [23]. Once the ecosystem or landscape function is known, the nature and magnitude of its value to human society can be analyzed and assessed through the goods and services provided by the ecosystem or landscape unit [13]. The evaluation of (agricultural) land function includes quantitative and spatial feature analysis [65]. The quantitative appraisal of land function mainly adopted the indicators' estimation method [31,34,66]. In addition, system science, entropy weight method, triangle model, and coupling coordination degree model are used to evaluate land multifunctionality and to analyze the relationship between land use sub-functions [53]. At the micro-scale, studies have used spatial analysis techniques and related models to discretize each index to achieve a multifunctional evaluation of land use on the unified standard grid cell [10]. The main methods of functional value evaluation include the equivalent factor approach [27], the analytic hierarchy process [67], and the monetization method [68].

4.3. The Tradeoff or Synergistic Relationship between Agricultural Land Functions

(Agricultural) land systems have many different functions. For example, farmland may also provide recreation or biodiversity conservation benefits. Land functions, such as biodiversity conservation and aesthetic and recreational value, were often byproducts of rural land use. Spatial planning and rural policies protect and enhance these functions in regions [9]. There are complex interactions among land use functions, including tradeoffs and synergies. The former refers to the ability of one land use function to reduce another, while the latter refers to the positive interaction between certain land use functions [10]. Therefore, it is crucial to consider the sum of functions to obtain the overall benefits a landscape provides to society [50]. Understanding the relationships among multiple (agricultural) land functions and their influencing factors could promote the balanced development of land use functions, which are of great significance for optimizing spatial patterns and promoting sustainable land use [11,69,70].

Analysis of the relationship between (agricultural) land functions involves two aspects: understanding the relationship between multiple land functions and selecting land use strategies with win–win outcomes, such as high biodiversity and other land functions [71]. The other is understanding the driving factors that affect the functional relationship and coordinating different land functions. For example, increased structural complexity in land systems (landscapes) enhances biodiversity without reducing agricultural production [72]. Moreover, in the face of continued urban growth, especially in peri-urban areas, land resources for agricultural activities are limited and diminishing. At the same time, competition for land use activities, such as recreation, nature conservation, and intensive agriculture, is increasing in the remaining open space [73]. Using the synergies of features to reduce conflicts could effectively safeguard the value of these features [41].

The research methods of land function relationships include qualitative descriptions and statistical analysis [70], qualitative description without explicit quantitative and spatial measures. Correlation analysis measures the degree of interaction between functions and is the most commonly used statistical analysis method. It mainly includes root mean squared error (RMSE) [74], coupling coordination degree model (CCDM) [53], bivariate spatial correlation [10], Pearson correlation analysis [69], and other methods. Meanwhile, research on driving factors of (agricultural) land function relationship was analyzed by some scholars with geographical detectors [70]. Spatial regression models include the spatial lag model (SLM) and spatial error model (SEM) [69].

4.4. Application of Agricultural Land Functions and Sustainability

Since the United Nations Conference on Environment and Development in 1992, sustainable development has been elevated to a comprehensive concept and a pioneering political plan for the future of humankind [75]. In 2015, the 70th session of the United Nations General Assembly released Changing Our World: The 2030 Agenda for Sustainable Development and endorsed 17 Sustainable Development Goals (SDGs) to address economic, social, and environmental issues in an integrated manner [76]. As the basis of human survival, the land system's sustainable use and management are considered pivotal issues in regional development and have received global attention [77–79]. Agricultural land systems have a hard link to Sustainable Development Goals SDG2, "End hunger, achieve food security and improved nutrition and promote sustainable agriculture", SDG13, "Take urgent action to combat climate change and its impacts", and SDG15, "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" [80].

Currently, many countries and regions face an increasing imbalance between natural resources and the environmental base in the process of urbanization and industrialization [11]. The basic idea of sustainability is to orient economic action and social balance efforts toward protecting the functions of the land system. Sustainable development models offer solutions to socio-economic and ecological problems and, thus, open up new perspectives. The land function provides an attempt to put forward and implement the concept of sustainable development in land use and land development. Functional analysis is one way to assess sustainability. A study illustrated the research framework of land use functions (LUFs) in the regional sustainability assessment [31], which mainly consists of four steps: (1) select indicators that have a direct or indirect causal relationship with regional land use function, and establish an indicator system covering the three pillars of sustainable development (economic, environmental, and social); (2) identify the importance of each indicator to regional sustainability using a weighting method; (3) assess the limits of regional sustainability with normalized index values; (4) calculate each land use function via integrated weighting, assessing the number of indicators in an unacceptable condition (not reaching a target or exceeding a threshold), and taking into account the indicator score relative to a threshold/target where appropriate. Land functions are an integrated approach to understanding the economic, environmental, and social impacts of land use change on sustainability and to determining the limits/thresholds/indicators of sustainable development of these functions based on defining and measuring functions [31]. In addition, agricultural multifunction is considered a significant concept in the research and decision making of sustainable agriculture [23].

5. Conclusions

The land function provides a good grasp for research on the agricultural land system. We conducted bibliometrics to analyze agricultural-land-function-related papers from the Web of Science Core Collection database from 1991 to 2021. Although it does not reflect the research status of all databases, its findings still tell a part of the story. It showed that the number of publications on agricultural land functions has increased in the past 30 years. The primary authors and institutions were distributed in the United States, China, and Europe. Land Use Policy, Agriculture, Ecosystems & Environment are important journals on agricultural land functions. Research on agricultural land functions could be divided into the initial, development, and prosperity stages. Among them, ecosystem services, land use, agriculture, remote sensing, biodiversity, land use change, and multifunctionality were the most co-occurring keywords and represented the research hotspot in this field. The research frontier of agricultural land function included the analysis of the interaction between land use pattern and land function, agricultural land function evaluation and valuation research, the study of the interaction and driving factors between agricultural land functions, and the study of the function and sustainable use of agricultural land. Future research on agricultural land function will likely focus on the integrated management of agricultural land systems, gradually serving human needs, such as food security, climate change, and sustainable land use.

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