 DOI: 10.19601/j.cnki.issn1943 - 9903.2018.7.012

Current Situation and Hot Spots of Domestic Climate Changes——Based on Bibliometric Analysis of CSSCI Source Periodicals in 1996 - 2016

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Abstract Climate change has become a global environmental issue concerned by the international community. Study on climate change has increasingly become a frontier for academics and scholars in all fields. From subjective judgment to objective measurement, CSSCI journal papers collected from the CNKI database in 1996 - 2016 were used. With the aid of bibliometric tools, it is a new attempt to explore the development thread of domestic climate change research and recent research hot spot within the framework of the climate change subject. It found that the current problems in the field of climate change research in China are as follows: (i) low research level and unbalanced discipline development, (ii) relatively spatially concentrated research institutions and relatively research direction, and (iii) single research perspective of the field of agricultural climate change and lack of agricultural adaptability studies.

Key words Bibliometric, Climate change, Research hot spot, Visualization

1 Introduction

Climate change is closely related to human production and life. According to the *Fifth Assessment Report of IPCC*, since the 1950s, the global climate change has been abnormal, the average temperature has risen, and extreme weather has occurred frequently, which has exerted a profound impact on various fields such as human survival, especially agriculture. In recent years, some domestic experts and scholars have studied China's climate change from different perspectives. Wang Yangjie *et al.* [1] summarized the impact of climate change on agriculture from the perspective of research progress in economics; Zhou Jiehong *et al.* [2] reviewed the progress in agricultural production transformation in response to climate change; Zhou Shudong *et al.* [3] analyzed and explored the impact of climate warming on crop yields. These reviews have summarized the research progress of domestic climate change from different perspectives, and provide some reference for understanding the current domestic research status. However, they are all based on a relatively small amount of literature, and they provide a comprehensive picture of climate change research. There are certain drawbacks of research fields of climate change. In this study, we applied bibliometrics method to analyze the current research status of domestic climate change based on a large sample size, to discuss research hot spots and development trends, to provide reference for scientific researchers and decision makers in various fields.

2 Data source and study method

2.1 Data collection In order to analyze domestic research trends and development frontier on climate change, we selected CNKI full-text database for the selection of research samples. The span of time retrieval is nearly 20 years, namely, from January 1996 to December 2016. The method of literature search is as follows: in the "Advanced Search" box of the journal, select the search scope "key words" and enter "climate change" in the search terms. The search time is from 1996 to 2016, and the journal source category is CSSCI. In order to eliminate the interference of irrelevant literature and ensure the credibility of the research results, the yearbooks, journals, and conferences were excluded, and 3 785 papers were obtained. In order to keep consistent with our research theme, namely the research on the impact of climate change on agriculture, the retrieved literature was further screened according to disciplines, selected agriculture-related disciplines "meteorology", "resource science" and "agricultural economy", the time is limited to the last ten years (namely, 2006 - 2016). Through deleting the repetitions, we finally obtained 439 related articles.

2.2 Research methods Bibliometrics, as a branch of informatics, is a scientific study of quantitative analysis of literature, and developed from the combination of scientometrics and bibliometrics[4]. At the end of the 20th century, bibliometrics was used to analyze the use of literature by agricultural science and technology personnel in China, to evaluate the level of agricultural high-efficiency research, to evaluate the academic level of journals of agricultural colleges, and to evaluate the comprehensive index of university science and technology literature. Since the beginning of the 21st century, bibliometrics has been widely applied in the dissertation statistics of various disciplines, analysis of development trend, the evaluation of the effect of journals or research institutions, including agricultural sciences, earth sciences, remote sensing sciences, biological sciences, atmospheric sciences, *etc.* Among these, the research by Scientific Information Center for Resources and Environment of Chinese Academy of Sciences is deep. The Citespace information visualization software was developed in 2004 by Dr. Chen Chaomei, a Chinese scholar. With its powerful and advanced features, the software has been widely used both at

Received: May 3, 2018 Accepted: July 12, 2018
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home and abroad. In foreign countries, the application of this software is mainly distributed in the fields of information science, life sciences; in China, it is mainly applied in the fields of management science and technical science. From the perspective of application field, it mainly includes library and information science, management science, science and technology policy, pedagogy, and specific technical science (nanoscience and technology, energy technology, new material technology, electronic information technology, *etc.*); it is mainly based on the research frontiers and research hot spots of knowledge maps, scientometrics and citation analysis, key word common word network analysis, author co-citation and author cooperation network analysis, *etc.* [5].

3 Research process and findings

3.1 Number of related papers The academic papers on climate change in the CSSCI database were analyzed from the time series, and the distribution of papers in recent 20 years was illustrated in Fig. 1. As can be seen from Fig. 1, domestic studies on climate change started in 1998. Prior to this, there were few related papers. According to the number of papers, it can be roughly divided into two stages: First, 1998 – 2006, in this period, the number of papers is small, the average annual number of papers was only 36, the overall growth tends was gentle. Second, 2007 – 2016, in this period, the number of papers showed a rapid growth and it reached the peak value in 2010 (607 papers, accounting for 16.04% of total samples), increasing by 85.63% compared with 2009, and the number of papers was nearly two times of that in the first stage (5.59%). The number of papers in the second stage accounted for 91.41%, and the annual number of papers was 346. It can be seen that the research on climate change is gradually becoming the focus of domestic scholars and various fields as the global climate and deterioration of environment. Particularly, in the past decade, it has become a research hot spot in academic circles and has received widespread attention from scholars.

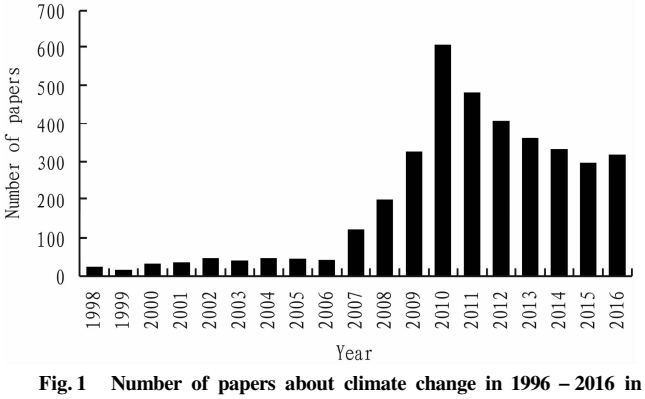

Fig. 1 Number of papers about climate change in 1996 – 2016 in CSSCI database

3.2 Distribution of foundations and research levels In terms of foundation distribution, foundations were mainly National Natural Science Foundation (546 papers) and National Social Science Foundation (366 papers), accounting for 39.45% and 26.45% of the total sample size. Besides, there were State Key Development Program of Basic Research of China, National Science and Technology Project of the Ministry of Science and Technology, China Postdoctoral Science Foundation, local foundations. These not only promote the constant deepening and expansion of the research in this field, but also give prominence to the concern of the country and various circles of the society. Although scholars' enthusiasm for research has been increasing and the efforts of the circles of the society are increasing, it is necessary to point out that China's current research in the field of climate change is still inadequate, a main problem is low research level and research is not professional and pertinent. Basic research took up the leading position, accounting for 76% (nearly 3/4) of the total research projects, while research fields such as higher education, professional and practical technology, and professional guidance for engineering and technology in the field of specialized research are less involved. In summary, China has a rigid demand for climate change and the social concern is high. However, at present, related scientific research is still at the starting stage, the discipline development is not balanced, the pertinence and practibility are to be strengthened, which raises higher requirements for scholars of related disciplines.

3.3 Statistics of highly productive authors and research institutions The development of a research field can not be separated from the hard work of various professional scholars. Among this, core authors play a backbone role in the research field. Thus, analyzing the research of core authors is helpful for making a macro grasp of mainstream research hot spots in a certain field. With the aid of the literature search function of the CNKI database, we identified the top ten authors in the research field of climate change in the past 20 years (Fig. 2).

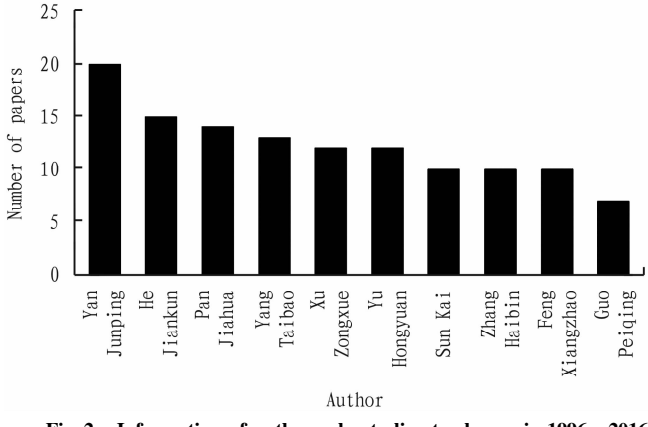

Fig. 2 Information of authors about climate change in 1996 – 2016 in CSSCI database

From Fig. 2, it can be seed that in 1996 – 2016, Professor Yan Junping from Shaanxi Normal University ranked first in the number of papers (he issued 20 papers), followed by He Jiankun from Tsinghua University and Pan Jiahua from Environmental Research and Development of the Chinese Academy of Social Sciences (issued 15 and 14 papers respectively). Authors who issued more than ten papers also included Yang Taibao, Xu Zongxue, Yu Hongyuan, Sun Kai, Zhang Haibin, and Feng Xiangzhao. The research fields of these productive scholars were mainly concen-

trated on meteorology, environmental science and resource utilization, macroeconomic management and sustainable development, and agricultural economy. Most authors came from colleges and universities, indicating that colleges and universities are the main research forces in the field of cooperatives. The top ten universities were Tsinghua University (118/14.18%), Renmin University of China (118/14.18%), Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences (110/13.22%), Peking University (81/9.74%), Beijing Normal University (74/8.89%), Wuhan University (72/8.65%), Shaanxi Normal University (67/8.05%), Lanzhou University (64/7.69%), Nanjing University of Information Science & Technology (64/7.69%), and Fudan University (64/7.69%). On the whole, these ten institutions issued 832 papers in total, accounting for 92.29% of the sample size, indicating that the scientific and technological research level of other institutions is to be further strengthened. In addition, top colleges and universities were mainly concentrated in the central and eastern part, especially the eastern coast, largely associated with the fact that scientific research funds were mainly many scientific research institutes in these areas. This also reflects climate change in these areas is more obvious, which is closely connected with human production and life.

3.4 Distribution of disciplines and periodicals The disciplines were mainly distributed in the fields of environmental science and resource utilization, meteorology, macroeconomic management, and sustainable development, accounting for 32.42%, 23.18%, and 10.72% respectively. The above three major disciplines accounted for nearly 70%. However, fields such as news and media, biology, power engineering, water conservancy and hydropower research, forestry, finance, *etc.* were involved, but related research was relatively inadequate and subject research was not deep enough. Through statistics of periodicals for papers about climate change in the CNKI database, we obtained the top ten periodicals and number of papers. Periodicals such as *Environmental Protection*, *Journal of Arid Land Resources and Environment*, *China Population Resources and Environment*, *Resources Science* were academic journals with relatively concentrated publication of the field change. The top ten periodicals issued a total of 992 papers accounting for 75.84% of the total sample size, indicating that periodicals with publication of climate change papers are several basic science periodicals, and few are social science and humanities science, manifesting concentrating on disciplines and focusing on theories.

3.5 Distribution of key words According to the statistics of sample key words, there were nearly 50 high-frequency words involved in 3 785 papers. To better explore the hot topics in climate change research in recent years, based on bibliometric analysis methods, we used key words ranked in the forefront of high-frequency key words, and extracted the top 30 key words (as listed in Table 1). High-frequency key words reflect the convergence of the attention of relevant researchers in the past 20 years and represent a research hot spot in this field. Table 1 indicates that the research fields of climate change in recent years involve a wide range of topics, including basic research on the measurement dimension of climate change itself, as well as studies and reflections on relevant social, economic, and political fields triggered by climate change. Besides, due to the special nature of climate change, its global and cooperative characteristics have also become increasingly prominent, making climate change become a research hot spot of researchers. Among these key words, low carbon economy had the highest frequency (194 times), indicating that the low carbon economy has received wide attention in the field of climate change research; other high frequent words included carbon emissions, China, sustainable development, precipitation, temperatures, greenhouse gases, carbon taxes, the European Union. These words appeared more than 30 times and could basically reflect main research hot spots of domestic climate change.

Table 1 Statistics of key words and centrality in CSSCI in recent ten years

No.	Key words	Frequency of use// times	Percentage %
1	Climate change	1 015	49.08
2	Low carbon economy	194	9.38
3	Carbon emissions	68	3.29
4	China	66	3.19
5	Sustainable development	49	2.37
6	Precipitation	47	2.27
7	Temperature	42	2.03
8	Greenhouse gases	41	1.98
9	Carbon taxes	36	1.74
10	EU	34	1.64
11	Effect	31	1.50
12	Emission reduction	30	1.45
13	Carbon trading	30	1.45
14	*Kyoto Protocol*	29	1.40
15	Low carbon city	28	1.35
16	Adaptation	28	1.35
17	Clean Development Mechanism (CDM)	26	1.26
18	USA	24	1.16
19	Global climate change	24	1.16
20	Arctic policy	24	1.16
21	Global governance	24	1.16
22	Carbon tariff	23	1.11
23	Energy conservation and emission reduction	23	1.11
24	Human activities	21	1.02
25	Low carbon development	20	0.97
26	Carbon emission reduction	20	0.97
27	Greenhouse gas emission reduction	20	0.97
28	International cooperation	18	0.87
29	Low carbon	17	0.82
30	Carbon finance	16	0.77

According to the frequency of use, we plotted the social network chart for high frequency key words (Fig. 3). It indicates that the research of climate change basically formed the knowledge network consisted of point, line, and plane. Key words in the core position included "low-carbon economy", "China", "global governance", "precipitation", and "carbon emissions". Focusing on the above hot spots, scholars have made extensive studies on cau-

ses, effects, and measures for climate change from different fields, and have obtained rich results.

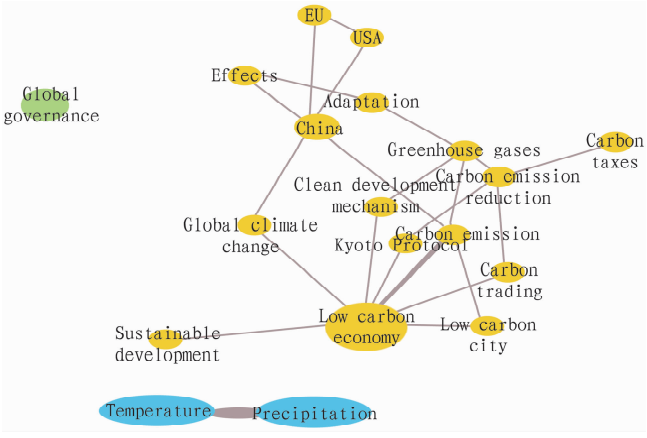

Fig. 3 Social network analysis chart for high frequent key words about climate change research in 1996 – 2016

4 Statistical analysis of agricultural research hot spots and research trends

Agriculture is the most sensitive and vulnerable area of climate change, and climate change will pose a certain threat to the grain security. In view of this, it is of great significance for making clear the research direction, deepening the agricultural field, and ensuring China's grain security. Through statistics of 439 papers, we obtained 365 key words, and selected 54 key words with frequency of use not less than two times, as shown in Table 2. Rejecting those completely repeated key words, we finally selected 50 key words as the research hot spot in the field of domestic climate change. From Fig. 4, it can be seen that top ten key words were climate change, precipitation, temperature, China, adaptation, low carbon agriculture, vulnerability, change trend, Inner Mongolia, and effect. All these words appeared more than six times. These key words could basically reflect the main research hot spots of climate change in domestic periodicals.

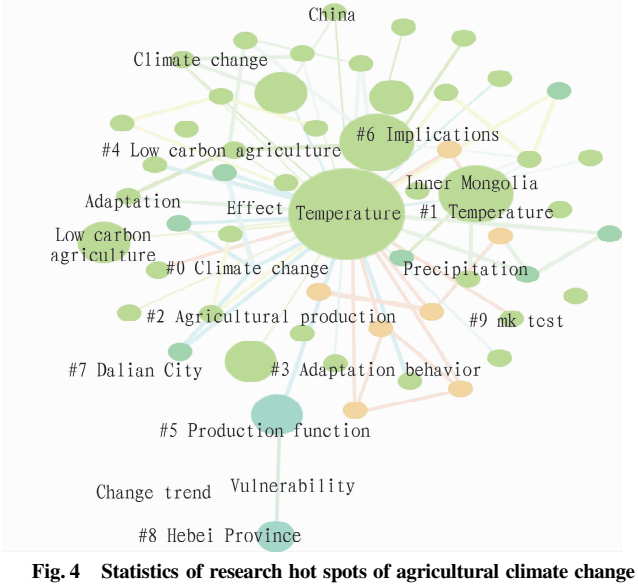

Fig. 4 Statistics of research hot spots of agricultural climate change

Table 2 Statistics of key words and centrality of literature about climate change and agriculture in CSSCI

Year	Key words	Frequency of use// times	Centrality
2006	Climate change	311	1.73
2007	Precipitation	30	0.01
	Agricultural production	4	0
	Adaptation behavior	4	0
	Extreme climate	2	0
	Policy	2	0
2008	Temperature	28	0.03
	Change trend	7	0.06
	Economic development	2	0
	Global warming	2	0
2009	Effect	6	0.02
	Northeast China	2	0
	Meteorological disaster	2	0
	Climate warming	2	0
2010	China	11	0
	Low carbon agriculture	8	0
	Inner Mongolia	6	0
	Trend	2	0
	Hebei Province	2	0
	Low carbon economy	2	0
	Sunshine hours	2	0
	Forest carbon sink	2	0
2011	Precipitation	5	0.02
	Luan River basin	2	0
	Spatial distribution	2	0
	Shaanxi Province	2	0
2012	Periodic	2	0
	Rural development	2	0
2013	Vulnerability	8	0
	Drought and flood disasters	3	0
	Wind velocity	2	0
	Trend analysis	2	0
2014	Adaptation	9	0
	Remote sensing	5	0
	Glacier retreat	2	0
	Carbon trading	2	0
	Statistical analysis	2	0
	Water loss and gain	2	0
	Losses and disasters	2	0
	Extreme rainfall	2	0
2015	Farmer households	4	0
	Production function	3	0
	Rice	2	0
	Paris Agreement	2	0
	Technology efficiency	2	0
2016	Grain security	4	0
	Adaptation	3	0

With the aid of Citespace software, we plotted the knowledge graph for evolution of key words about research of climate change (Fig. 3). Key words with higher centrality were low carbon agri-

culture, precipitation, temperature, adaptation, China, agricultural production, farmer households, and grain security. These words can be used to analyze the research trend of climate change in agricultural field. Key words in recent decade can be divided into three types: (i) farmers' perceptions and adaptations to climate change, (ii) effect of climate change on China's agricultural production and grain security, and (iii) development path of low carbon agriculture.

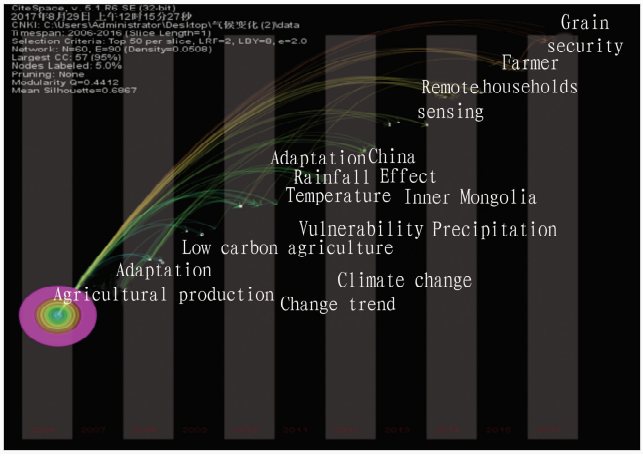

Fig. 5 Evolution of high frequent key words about climate change in 1996 – 2016

5 Discussions about research hot spots of climate change

Using log-likelihood ratio (LLR) ordering algorithm, we extracted high frequent key words as clustering markers, which can reflect hot spots of domestic climate change research (Fig. 6). According to clustering results of Citespace and themes involved in literature, we summarized the following research hot spots:

Top 2 Key words with the strongest citation bursts

Key words	Year	Strength	Begin	End	2006-2016
Change trend	2006	2.981 8	2008	2010	
Adaptation	2006	3.854 2	2014	2016	

Fig. 6 Research hot spots of climate change in agriculture

5.1 Effect of climate change on agricultural production

Agriculture is the sector with highest effect of climate change[6]. On the one hand, climate change will directly effect the growth and development of crops through changes in precipitation and temperature distribution. On the other hand, climate change may change the survival, development and performance of pests or weeds and other organisms due to changes in conditions such as temperature and water, accordingly it indirectly harms crop growth or yield[7]. These direct or indirect effects have intensified the conflict between the agricultural production potential and the effective supply of agricultural resources. These promote frequent occurrence of agricultural meteorological disasters in some areas, and pose different degrees of threats to the grain security. Through reading the literature, scholars have focused on the following aspects of the effect of climate change on agricultural production.

(i) Climate change influences the distribution and structure of agricultural production. Agricultural climate resources mainly include light resources, thermal resources, and water resources. The effect of climate change on agricultural production is first manifested in the quantity and configuration of agricultural climate resources, leading to effect on agricultural production process, and ultimately influencing agricultural planting system, crop distribution, growth development and yield formation, and the degree of effect varies depending on areas. (ii) Climate change influences crop growth and development. Temperature is a key factor influencing the speed of crop development, and the temperature determines the duration of the growth period. As the temperature rises, the crop growth period is generally shortened. Taking rice as an example, studies have shown that the effects of rising temperature on the growth and development of rice varieties with different maturity are different. For example, in Guangdong, in the past 20 years, the development period of early rice has different degrees of advancing, and the development period of late rice is constantly delayed, and the days of whole growth period of early rice and late rice varieties are gradually shortened. (iii) Climate change influences crop yield. The effect of climate change on crop is ultimately manifested in the yield, and positive and negative effect of climate change is not even in the world, and the change in crop yield is not consistent. Some studies indicate that under future climate conditions, temperatures increase, crops grow faster, growth periods shorten, then different rice varieties will have different declines in the yield, 3.7% for early rice, 10.5% for middle maturing rice, and 10.4% for late maturing rice[8]. The change trend of the inter-regional production is also different. In the future, the precipitation will increase. The yield of rain-fed winter wheat in North China and the middle and lower reaches of the Yangtze River will increase, while the winter wheat in the Northeast and Northwest China will have a trend of yield decrease.

5.2 Methods for evaluating the effect of climate change on agricultural production From the perspective of research methods, the current models for evaluating the effects of climate change on agriculture are mainly divided into two major categories: the crop mechanism model and the econometric model. The crop growth model is mainly based on crop production theories and controlled production experiment, and discusses the response and mechanism of crops to different ecological and environmental factors at various growth stages. However, due to the complexity and uncertainties of the crop growth process, a large number of parameters need to be assumed. Experiments or studies provided by the crop mechanism model do not consider farmers' adaptation to climate change and may overestimate the negative effects of climate change on agriculture. Based on historical data and climatic conditions, the econometric model uses empirical measurement methods to study the impact of climate factors such as temperature and precipitation on crop yields or agricultural profits. Compared with the crop mechanism model, the econometric model can incorporate producer adaptation behavior into the analytical framework of effects of climate change on agriculture.

5.3 Effect of current agricultural production methods on climate change High carbon agriculture, characterized by high

input, high consumption, and low efficiency, is the main source of agricultural greenhouse gases and is also the main cause of global warming[9]. Now, agriculture has become the second largest source of greenhouse gases. Take N_2O as an example, the nitrous oxide emitted by the world agriculture accounts for 60% – 80% of the total emissions. China is the world's largest agricultural producer. The long-term extensive production methods ensure the crop yield, but neglect the environmental protection, and the greenhouse gas emission is also higher than the world average. Domestic research on agricultural production methods mainly focuses on low carbon agriculture. The research mainly focused on five methods: (i) the definition of low carbon agriculture, (ii) the measurement of low carbon agriculture, (iii) the challenges faced by low carbon agriculture, (iv) the development path of low carbon agriculture, and (v) low carbon agricultural development learning international experience.

5.4 Farmers' perception and adaptation to climate change

The adaptability of climate change as a frontier and core issue in the study of sustainable development has gradually attracted global attention in the academic circle. For China, it is a practical and urgent mission to adapt to climate change. Scholars have made extensive studies on how to mitigate the effect of climate change and how to adapt it to specific practices, and have made certain achievements, but there are also many problems. Specific studies can be divided into the following aspects: (i) the obstacles faced by farmer households when adapting to climate change, (ii) the relationship between farmers' perceptions of climate change and adaptation, (iii) the ability of farmers to adapt and their evaluation, and (iv) the evaluation and development of climate change adaptation strategies of farmers. The formulation and implementation of climate change adaptation policies are also an important part of adaptation work[10] and are an important guarantee for the effective implementation of national and local adaptation goals. Therefore, it is required to pay special attention.

6 Conclusions and prospects

In conclusion, there are following weak points in research of climate change. (i) Research level is not high and discipline development is not balanced. The research is concentrated on the field of basic research. It is not practical and comprehensive enough, and discipline barrier is relatively obvious. Take agriculture as an example, it fails to combine climate change model and crop growth model in natural and academic fields, response behavior of farmers to climate change at micro level, and social and economic factors such as agricultural policies at macro level, leading to difference of effects of climate change on the agricultural production. (ii) The research institutions are relatively concentrated in regions and their research directions are relatively single. Research institutions and researchers are mainly distributed in central and eastern colleges, universities, and research institutes, indicating that the research contents are mainly basic science periodicals of resource environment, few periodicals are social science and humanities, indicating that concentrated fields of disciplines and theories. (iii) The perspective of research of agricultural climate change is relatively single, and agricultural adaptability research is inadequate. The research of agricultural climate change is mainly concentrated on economic effect, and the attention is mainly paid to effect of climate change on agriculture (yield and efficiency), while there is little research about the transformation of agricultural production. For specific studies, case studies are extensive, but there are few studies from cases to theoretical level.

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