

Study on Comprehensive Assessment of the Sustainable Development of Agricultural System

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Abstract—Based on bibliometrics and knowledge mapping, 305 literatures related to sustainable development of agricultural systems in CNKI database were visualized and analyzed on CiteSpace. This study studies the hot spots and trends of this topic from three aspects: publication volume, publication keyword and publication source (institution and journal). The research findings are as follows: (1) the number of articles published fluctuates constantly and tends to be stable in recent years, but not as high as the peak period; (2) the previous hot topics also gradually fade away, and more deeper research is needed to excavate the emerging themes; (3) a core group of journals, including Journal of Ecology, Anhui Agricultural Sciences, Research of Soil and Water Conservation, and Chinese Journal of Eco-Agriculture, has been formed on the publication carrier. In addition, research centers on the sustainable development of agricultural systems have been established nationwide, represented by the Chinese Academy of Sciences, the Research and Monitoring Institute of Environmental Protection of the Ministry of Agriculture and Rural Affairs, and central South University of Forestry and Technology. But the cooperation network between different institutions is not obvious. Finally, this study discusses and expands new research methods, including grounded theory to construct theoretical models, subjective and objective evaluation methods to quantify qualitative indicators, and construct linear models. This study aims to break through the research bottleneck, develop new research results and provide new ideas for rural revitalization.

Keywords-Agricultural system; Sustainable development; Bibliometrics; Comprehensive assessment

1. Introduction

In recent years, a large amount of literature will explore agricultural systems from different perspectives such as social, ecological, economic ^[1], digital information systems ^{[2][3]} and so on. It is important to explore the sustainable development of agricultural systems for rural revitalization. Based on the literature data from 1995-2022 in CNKI database, this study uses CiteSpace information visualization tool and combines bibliometrics and knowledge map analysis to review the research status and hot spots in terms of the number of publications, keywords, publishing institutions and journals. So it can provide reference for the follow-up study of rural revitalization and agricultural sustainable development ^[4]. This study further discusses the method path of the influencing factors and its evaluation, which can provide methods and practical references for subsequent rural revitalization, sustainable agricultural development and other rural revitalization related research.

2. Research method and data source

2.1 Research method

This study combines the methods of bibliometrics and knowledge graph. The former uses quantitative research methods such as the Bradford Method and mathematical statistics to objectively evaluate and reflect the research status and development process of different research institutions and journals in a certain field ^[5]. The study uses CiteSpace to export selected literatures from CNKI database, and makes “keyword”, “journal” and “institution” as analysis objects to draw analysis maps. This method can transform the effective information of many literatures into visual charts, in order to show more intuitively display the hidden rules and the internal relationship between different research categories, and thus provide scientific basis for scientifically and effectively predicting the development trend and trend of research in a certain field ^[6].

2.2 Data source

The data of this study are from core journals, CSSCI journals and CSCD journals included in CNKI full-text database. Keywords "agricultural system" and "sustainable development" were selected for retrieval, and literatures that did not conform to the theme were deleted. The retrieval date was up to November 8th, 2022, and 305 valid literatures were finally obtained as the objects of analysis and research.

3. Results and analysis

3.1 Analysis of publication volume

The change of the publication volume can visually reflect the development trend of some subject and the change of the research trend in a certain time period, which is of great significance to the future development trend of research ^[7]. As can be seen from Figure 1, relevant studies on sustainable development of agricultural systems are in constant change. The number of published papers fluctuates significantly in the past decade, with an obvious downward trend. However, under the influence of the country's rural revitalization strategy, the number of published papers gradually tends to be stable in the past five years.

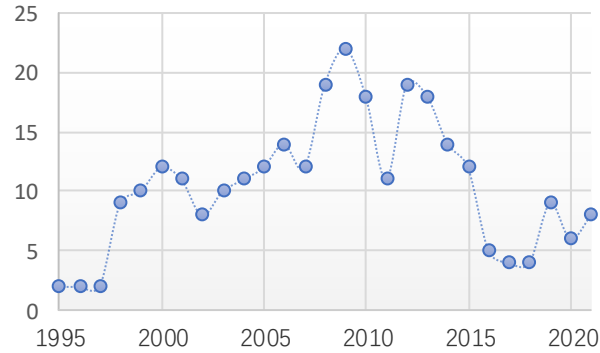


Fig.1 Annual publication volume statistics

3.2 Keyword analysis

3.2.1 Keyword co-occurrence analysis

In general, the higher the frequency of keywords, the higher the hotspot of the topic ^[8]. Excluding the keywords contained in the search formula, "emergy analysis" is the keyword with the most occurrences and the strongest centrality, as shown in Figure 2. In generally, "emergy analysis" is the main analytical method used in this research. Evaluation index system, ecological agriculture, ecological economy, development mode and mechanism are the most studied contents.

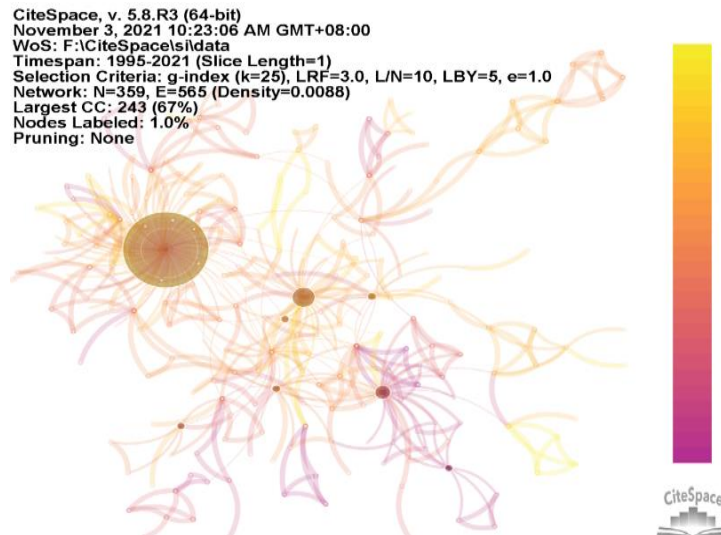


Fig.2 Keyword co-occurrence network analysis

3.2.2 Analysis of Research and Development Process

Time graph can be seen that different stages of the hot spot content. As shown in figure 3, the study of sustainable agriculture, from the beginning to the “emergy analysis” method of popular around 2004, the relevant research literature, its model, mechanism, evaluation index part always has been the focus of research over the years. And in recent years, it has not yet formed a new research hotspot.

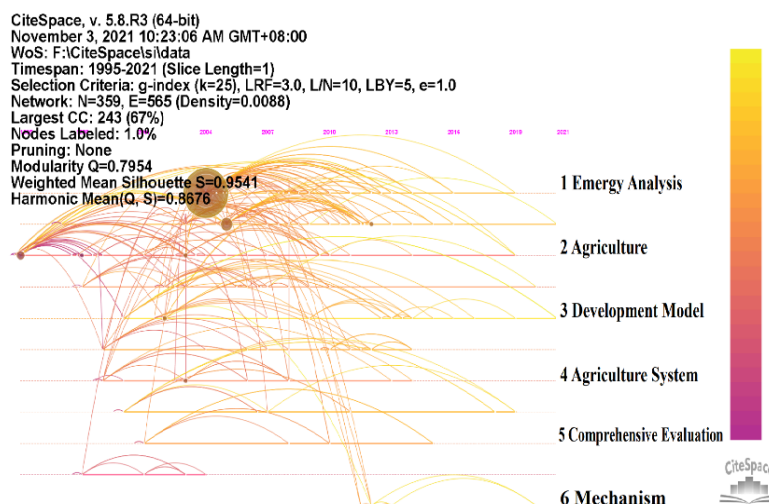


Fig.3 Keyword timing diagram

3.3 Analysis of published sources

3.3.1 Analysis of published journals

The analysis of literature source journals is helpful to understand the core group of journals in this research field, and has reference significance for scholars to collect literature and select publication platform. A total of 89 articles were published in 7 or more periodicals in the 305 documents screened for this article. Among them, Journal of Ecology topped the list with 16 articles. According to Bradford Method:

$$r_0 = 2 \ln(e^E \times Y) \quad (1).$$

“ r_0 ” represents the number of periodicals in the core area; $E=0.5772$, indicating Euler coefficient, “ Y ” refers to the maximum number of articles in a journal [19]. In this study, $Y=16$, so the integer value of “ r_0 ” is about 7, that is, there are 7 journals in the core area. As shown in Table 1, the top seven journals are the major core journals that currently publish the research results of sustainable development of agricultural systems.

Table 1 Journals publishing more than 6 articles

No.	Journal	Count
1	Journal of Ecology	16
2	Anhui Agricultural Sciences	14

3	Soil and Water Conservation Research	12
4	Chinese Journal of Eco-Agriculture	12
5	Agricultural Modernization Study	10
6	World Agriculture	8

3.3.2 Analysis of issuing agency

According to the statistics of major publishing institutions, 97 publishing institutions are involved in this study, and 8 institutions have published more than 5 articles, as shown in Table 2. Among them, the Chinese Academy of Sciences published the most papers with 43. Followed by the Environmental Protection Research and Monitoring Institute of the Ministry of Agriculture and Rural Affairs (27), the rest 11 or less. In addition, the centrality of issuing agencies is low and the cooperation relationship between them is weak.

Table 2 Main issuing institutions

No.	Institutions	Count
1	Chinese Academy of Sciences	43
2	Ministry of Agriculture and Rural Affairs of Environmental Protection Research and Monitoring Institute	27
3	Central South University of Forestry and Technology	11
4	Fujian Normal University	8
5	Northwest Normal University	8
6	Hebei Agricultural University	7
7	Hunan Agricultural University	6
8	Gansu Agricultural University	5
9	Nanjing Agricultural University	5

4. Discussion and expansion

The sustainable development of the agricultural system is an important way to achieve efficient transformation and utilization of agricultural value in rural revitalization, affecting the sustainability of rural economy, society and environment. And the study of its influencing factors is a major issue that needs to be solved urgently in rural revitalization. Based on the visual analysis results of CiteSpace, the distribution of related hot words can be intuitively visualized, but most of the influencing factors cannot be quantified and require specialized research. Therefore, research can be based on grounded theory, conduct interviews and research, and obtain first-hand data. According to the three-level coding construction theory, the subjective and objective comprehensive evaluation of the research results or the construction of multi-layer linear models, can serve the sustainable development ability of different agricultural production systems.

4.1 Comprehensive evaluation method

4.1.1 Determination of objective weights

In the grounded theory research, the data processing stage will encode the original data, and the open encoding formed is a simplified and abstract representation of the original text data, so the core category can be used to support a correspondence between the number of codes and the text data for the calculation of word frequency weights. Based on the characteristics of coding processing, the calculation of weights can adopt the word frequency weight method, and the coding frequency and weight of each influencing factor can be obtained according to the coding results, and the formula is:

$$w_k = \frac{k}{\sum_{i=1}^k i} (2).$$

Since only one research idea and method is shown here, I will temporarily take the keywords made by CiteSpace (merging words with similar meanings and removing words that do not meet the influencing factors) of the above study as an example to show the weight calculation results. Five main influencing factors and their weights can be derived, as shown in Table 3 (due to space limitations, only the weights of the underlying level indicators are shown). *And the weight vector table is: $w = (w_1, w_2, w_3, w_4, w_5) = (0.361, 0.180, 0.157, 0.157, 0.145)$.*

Table 3 Frequencies and weights of influencing factors

Influencing factors	Frequency	Weights
Food Security	30	0.361
Ecological Agriculture	15	0.180
Grassland Agriculture	13	0.157
Agricultural Engineering	13	0.157
Circular Economy	12	0.145

4.1.2 Determination of subjective weights

Using the Analytic Hierarchy Process (AHP) to calculate the index weights. First of all, experts are required to score the relevant indicators, and then through the calculation of AHP rules: construct a hierarchical model, judgment matrices. Finally, the researcher can obtain the indicator weight vector as $w = (w_1, w_2, \dots, w_n)$ and make a consistency judgment. Due to space limitations, the steps of the method of AHP are omitted here.

4.1.3 Fuzzy comprehensive evaluation method

In actual research, the indicators for research are qualitative indicators, so fuzzy statistics are used to determine their membership function. The end result is a comparison of the sustainability of multiple agricultural production systems. Based on the basic indicator set and evaluation level criteria that have been determined, a questionnaire is produced, experts are invited to make evaluations, score and determine the most preferred level on the basis of all the grades given, and after multiple comparisons and evaluations, the frequency of each indicator in the determined different evaluation levels is counted, and the degree of belonging is obtained by normalization. The membership vector of each indicator in each indicator set "U" is combined as a column vector into a matrix of order "j" multiplied by "n", that is, the fuzzy evaluation matrix "R".

$$R = \begin{bmatrix} r_{11} & \cdots & r_{n1} \\ \vdots & \ddots & \vdots \\ r_{jn} & \cdots & r_{jn} \end{bmatrix} \quad (3).$$

Taking the above table weights as an example, an indicator set $U = (u_1, u_2, \dots, u_k)$ has a fuzzy comprehensive evaluation matrix of R . Then combined with the weight vector w obtained according to the subjective and objective comprehensive empowerment method, the fuzzy comprehensive evaluation vector of “ U ” is calculated:

$$F = w \times R \quad (4).$$

4.2 Multilayer linear model measurement method

In addition to the comprehensive evaluation method described above, building a multilayer linear model can also transform core concepts into measurable metrics. The research needs to be measured by a multi-layer linear model, and the measurement index is the independent variable in the model, which is divided into intermediate layer variable and basic layer variable, and the synthesis method is weighted linear sum method. This is based on the independent consideration between several major influencing factors and their sub-factors derived from the study of grounded theory. Measurement models use multilayer linear models that can be expressed as:

$$I = w_1 f_1 + w_2 f_2 + \cdots + w_n f_n \quad (5).$$

In the formula, w_1, w_2, \dots, w_n are the factors each weighted in the measurement model, all greater than 0, the formula is shown in formula (5), and $w_1 + w_2 + \cdots + w_n = 1$; f_1, f_2, \dots, f_n are the study variables. Combined with the grounded theory, there are multiple base layer variables below each intermediate layer variable, which can refer to the above formula, and finally the variable measurement model of the core factor can be calculated. The model only needs to measure the primary variable to finally calculate the dependent variable.

5. Conclusion

Since 1995, the output of literature on the sustainable development of agricultural systems has fluctuated continuously, and has begun to stabilize in recent years, but the number of papers is not as high as the peak, and the previous hot topics are gradually fading, which requires further research and mining of emerging themes. Among the major quality periodical publishing platforms, the core periodical group consisting of Journal of Ecology, Anhui Agricultural Sciences, Research of Soil and Water Conservation and Chinese Journal of Ecological Agriculture has been formed on the publication carrier. In addition, research centers on sustainable development of agricultural systems have been established nationwide, with the Chinese Academy of Sciences, the Research and Monitoring Institute of Environmental Protection of the Ministry of Agriculture and Rural Affairs and the Central South University of Forestry and Technology as representatives, but the network of cooperation between different institutions needs to be strengthened.

Although sustainable development of agricultural systems is not a new concept, it is a key agricultural research direction under the rural revitalization strategy. This study proposes to conduct a grounded theoretical study on the sustainable development of agricultural systems by means of interviews and research. Depending on the specific situation, the quantification of the

indicators of the relevant concepts obtained by it can be measured by a comprehensive evaluation method or a multi-level linear model to serve the purpose of comparing the sustainable development capabilities of different agricultural systems. Among them, the combination of subjective and objective evaluation methods can further improve the scientific nature of research. This research path not only constructs a sustainable development model of agricultural systems and enriches the theoretical results, but also quantifies qualitative indicators through corresponding model calculation methods to improve the practicality of the results.

Based on the above conclusions, the following scholars can deepen and expand the research content from the perspective of multidisciplinary research, and comprehensively apply multivariate analysis methods, multi-level fuzzy comprehensive evaluation method and so on, in order to break through the research bottleneck, develop new research results and provide new ideas for rural revitalization.

Acknowledgments

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