

# Visualized Analysis of Ecological Governance Research Overseas

Dan Wu<sup>1</sup> Jiangan Chen<sup>2</sup>

<sup>1,2</sup> *School of Economics Management, North China University of Technology, Beijing 100144, China*

<sup>1</sup> *Corresponding author. Email: wudan@mail.ncut.edu.cn*

## ABSTRACT

Based on 795 SSCI and SCI literature on ecological governance and environmental governance in the WOS core database from 1998 to 2020, this study uses Citespace software to conduct scientific econometric analysis and visualization research on the research status, cooperation network, research hotspots, and research frontiers in this field. Research has found that from 1998 to 2020, the overall number of publications in this field steadily increased, with distinct stage characteristics; The research institutions are mainly centered around Stockholm University, maintaining close cooperative relationships between various institutions and forming a relatively wide range of research collaboration groups; Research hotspots in this field include "environmental governance", "climate change", "sustainability", "environmental protection", and related "systems"; The research topics of ecological governance overseas are nested, mainly including the study of ecological governance models, social ecological system governance, and ecological governance systems.

**Keywords:** *Citespace, Ecological governance, Knowledge graph, Research hotspots.*

## 1. INTRODUCTION

Due to the continuous challenges faced by the ecological environment that people rely on for survival, such as climate change, biodiversity loss, and air and water pollution, global environmental problems are becoming increasingly prominent. Therefore, policies and initiatives related to the ecological environment have emerged, such as the 2019 EU Green Agreement, the 2020 Global Biodiversity Framework (GBF), and the United Nations declaration of 2021-2030 as the Decade of Ecosystem Restoration. The ecological challenges faced by different countries and regions have commonalities, and the international community's shared concern for the ecological environment has driven global research on ecological governance. Therefore, conducting visual analysis and research on SSCI and SCI journal literature related to ecological governance in the Web of Sciences database is of great significance for gaining a deeper understanding of research hotspots, frontiers, and future research directions in the field of ecological governance.

## 2. ANALYSIS OF LITERATURE CHARACTERISTICS

To systematically analyze and grasp the research status and hotspots in the field of ecological governance in Chinese and foreign academia, based on the Web of Science database, SSCI and SCI source journals from 1998 to 2020 were selected as research samples. In the advanced search, relevant literature was retrieved based on the themes of "ecological governance" and "environmental governance". After excluding reports, conference notices, documents, call for papers, and introductory remarks, a total of 795 articles were obtained.

By sorting out the publication volume of various years in the field of ecological governance in WOS core journals, it can be found that from 1998 to 2020, the publication volume of foreign journals generally showed a steady upward trend, with clear stage characteristics, as shown in "Figure 1".

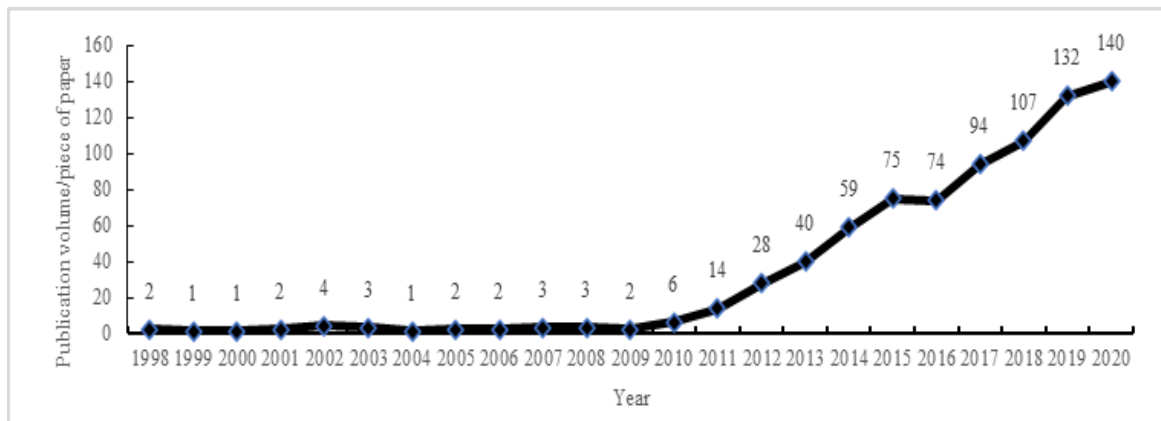


Figure 1 Publication volume of WOS journals on ecological governance research overseas from 1998 to 2020.

Specifically, it can be divided into two stages: the initial stage (1998-2009), with a total of 26 articles published, and an average annual publication of less than 3 articles. During this period, scholars' attention to research in the field of ecological governance was relatively low; During the rapid growth phase (2010-2020), the average annual publication volume reached 69 articles. The reason for this is that during this stage, environmental issues such as global climate change, species extinction, and land degradation have become increasingly prominent, forcing people to continuously increase their demand and attention to ecological governance. Secondly, since the

Copenhagen Climate Conference in 2009 and the Paris Agreement in 2015, international environmental agreements have raised global awareness and attention to climate change and other environmental challenges, thereby encouraging and prompting scholars to conduct in-depth research on the theory and practice of ecological governance.

### 2.1 Distribution of Institutional Cooperation

Using Citespace visualization analysis software, the top eleven institutions in terms of publication volume were obtained (see "Table 1").

Table 1. Number of publications by top eleven universities and research institutions in the field of ecological governance research abroad from 1998 to 2020

Serial number	Unit name	Publication volume
1	United States Environmental Protection Agency	25
2	Oregon State University	25
3	Helmholtz Center for Environmental Research	24
4	University of Montana	21
5	Montana State University	21
6	Swedish University of Agricultural Sciences	21
7	Stockholm University	20
8	University of Arizona	19
9	United States Geological Survey	19
10	Idaho State University	18
11	United States Department of the Interior	18

The top eleven universities and institutions in Table 1 have a total of 231 publications, accounting for 29.1% of the total publications. Among them, the United States Environmental Protection Agency

and Oregon State University rank first in terms of publications, each accounting for 3.1% of the total publications; The Helmholtz Environmental Research Center ranks second in terms of

publication volume, accounting for 3%; The third ranked universities and research institutions are the University of Montana, Montana State University, and the Swedish University of Agricultural Sciences. Montana, located in the northwest of the United States, is facing severe environmental problems. The reason for this is that the state's economy is mainly based on agriculture and animal husbandry, and mining and logging industries are also important industries. Therefore, colleges and

universities in the state attach great importance to the field of environmental governance research. Overall, colleges and universities and research institutions are the main force in the field of ecological governance research, and to some extent, they are related to regional characteristics.

Using Citespace visualization analysis software, a network graph of institutional cooperation was obtained (see "Figure 2").



Figure 2 Institutional cooperation map of ecological governance research overseas from 1998 to 2020.

In the institutional collaboration graph, the larger the font size, the more publications the institution has in the field, and the connecting lines represent the collaborative relationships between institutions. The thicker the connection, the closer the cooperation. The absence of a connection indicates no cooperative relationship. In addition, in CiteSpace, there may not be a direct relationship between the centrality indicator of institutional collaboration graph and the number of institutional publications. The centrality of the institutional collaboration graph mainly reflects the importance and influence of institutions in the collaborative network, while the number of publications by institutions reflects more of their research output. The relationship between these two may overlap, but it is not necessarily the case.[1] As shown in "Figure 2", the cooperation between universities and research institutions in this research field is mainly centered around Stockholm University, with California General University as the secondary core. From the dense connections, it can be seen that

various universities and research institutions maintain close cooperative relationships, forming a wide range of research cooperation groups, such as the Gall Stockholm University - Helmholtz Association - Rheinna University in Lüneburg and California General University - Exeter University - University of Edinburgh - Colorado State University - Leeds University and the United States Environmental Protection Agency - Swedish University of Agricultural Sciences - US Department of Agriculture - Florida State University - Australian National University and other institutional cooperation groups. There are also some independent research institutions, such as the University of London, the University of Waterloo, and the Autonomous University of Barcelona.

## 2.2 Characteristics of Author Collaboration

Based on the author collaboration situation, Citespace was used to generate the author collaboration collinear graph (see “Figure 3”). The



Figure 3 Author co-occurrence map of ecological governance research in WOS journals from 1998 to 2020.

Overall, the network density of author collaborations in the field of ecological governance from 1998 to 2020 was 0.013, indicating a relatively high degree of author collaboration in this research area. The color depth and thickness of the connections between authors can reflect the degree of cooperation between scholars, as shown in “Figure 3”. The collaborative relationship between authors in this field is extremely close, mainly in research groups with multiple authors. Currently, five main author collaboration groups have been formed, namely the research group led by Chaffin Brian C and Garmestani Ahjond S, the research group led by Bodin Orjan, Berkes Fikret, Armitage Derek, the research group led by Cox Michael, Ban Natalie C, the research group consisting of 10 individuals, including Jafferly Deirdre, Mistry Jayalaxhmi, Xavier Rebecca, and the research group consisting of 8 individuals, including Dei Corral D, Ferman JL, Camino M.

At the same time, drawing on the formula used by renowned scientometric expert Price to define high-yield scholars,[2] the core authors of this research field were selected, namely

$$m = 0.749\sqrt{n_{\max}} \quad (1)$$

author collaboration directly reflects the research achievements and academic sharing in the field of ecological governance, which is conducive to improving the quality and academic influence of scholars' research results in this field.

In equation (1), represents the lower limit of the number of publications by core authors;  $n_{\max}$  is the total number of publications by the most productive scholars in this field.

According to equation (1), the researchers select the number of publications by the author with the highest publication volume in this field, which is 4, as the reference value, i.e.  $n_{\max}=15$ . After calculation,  $m=2.90$ , indicating that a core author is one who has published more than 3 articles. According to the screening criteria, the core authors with a publication volume of 10 articles in this field can be obtained by reviewing the literature, as shown in “Table 2”.

Table 2. Core authors with 10 publications in the field of international ecological research by WOS from 1998 to 2020

Frequency of publication	Core author(s)	Number of people
15	Chaffin Brian C	1
12	Allen Craig R	1
11	Garmestani Ahjond S	1
10	Xavier Rebecca, Davis Odacy, Decaro Daniel A, Benjamin Ryan, Arnold Craig Anthony, Tschirhart Celine, Mistry Jayalaxshmi, Hayne Lakeram, Ruh J B, Schlager Edella, Berardi Andrea, de ville Geraud, Albert Grace, Jafferally Deirdre, Bignante Elisa, Gosnell Hanna	16

According to “Table 2”, Chaffin Brian C has published 15 articles in the field of ecological governance, ranking first, followed by Allen Craig R and Garmestani Ahjond S, ranking second and third respectively. According to Leps' Law, the number of publications by core authors in the research field should account for 50% of the total publications. The central author represents the backbone of the research. According to statistics, 107 core authors in this field have published a total of 566 articles, accounting for 71.1% of the total journal literature in this field. Therefore, the research in this field has formed core author groups.

### 3. ANALYSIS OF RESEARCH HOTSPOTS

#### 3.1 Hot Keyword Analysis

##### 3.1.1 Keyword Co-occurrence Analysis

Keywords represent the core topics and research areas of the literature, and high-frequency keywords in the literature can be considered as research hotspots in that field.[3] By conducting keyword co-occurrence analysis on SSCI and SCI journal literature on ecological governance research in WOS core journals from 1998 to 2020, a keyword co-occurrence network graph was obtained (see “Figure 4”).

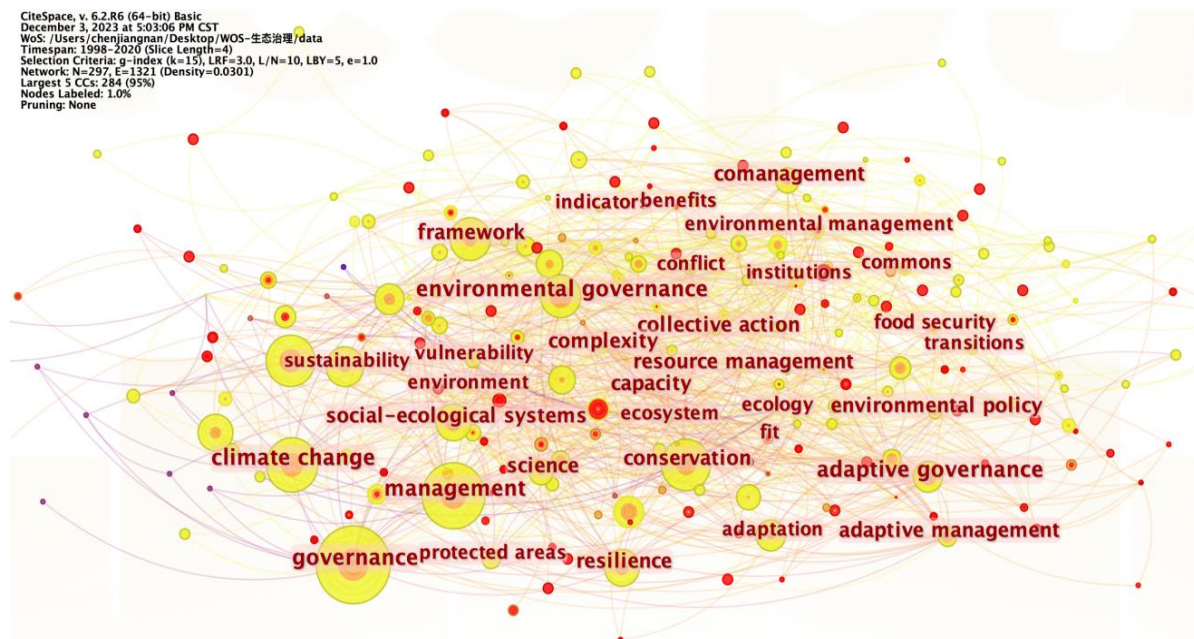


Figure 4 Keyword co-occurrence graph of WOS ecological governance research from 1998 to 2020.

In “Figure 4”, the keyword co-occurrence network graph contains a total of 297 nodes, 1321 connections, and a network density of 0.0301. The thickness of the tree rings represents the frequency of keyword occurrence, and the node thickness of the "governance" keyword node is the largest, indicating its highest frequency of occurrence; And the nodes of "management", "climate change", "sustainability", "conservation", "environmental governance" and "framework" have a large thickness and high frequency of occurrence. It indicates that research on "environmental governance", "climate change", "sustainability",

"environmental protection", and related "systems" are all hot topics in this field.

### 3.1.2 Keyword Emergence Distribution

Emergent analysis is commonly used to explore new research problems and trends in a certain research field, reflecting the dynamic changes at the forefront of research.<sup>[6]</sup> Based on “Figure 4”, the mutation distribution of the top 17 keywords in foreign ecological governance research was obtained (as shown in “Table 3”).

Table 3. Distribution of keywords on ecological governance in WOS journals from 1998 to 2020

Keywords	Year	Strength	Begin	End	1998—2020
adaptive comanagement	2010	2.98	2010	2017	
ecological modernization	2014	2.86	2014	2017	
environmental management	2011	2.32	2011	2017	
river	2014	2.28	2014	2017	
resilience	2010	3.15	2010	2013	
protected areas	2012	2.82	2012	2017	
multilevel governance	2015	2.13	2015	2017	
livelihoods	2015	2.13	2015	2017	
ecosystem approach	2014	2.09	2014	2017	
science	2010	2.57	2010	2013	
australia	2015	2.44	2015	2017	
food security	2012	2.38	2012	2013	
ecological restoration	2016	2.26	2016	2017	
stakeholder participation	2015	2.23	2015	2017	
fit	2012	2.15	2012	2013	
biodiversity conservation	2011	2.12	2014	2020	
regime shifts	2014	2.11	2014	2017	

According to “Table 3”, it can be seen that the sudden change in research in the field of ecological governance mainly began in 2010, based on the temporal distribution of the emergence. This is related to the relatively low number of journal publications on research in this field from 1998 to 2009, which is the initial stage of research in this field. At the same time, the emergence of keywords in the emergence table is concentrated between 2014 and 2017, indicating that there were many research frontiers in the field of ecological governance during this period. Upon investigation, with the increasingly severe global environmental problems, the United Nations has proposed the Sustainable Development Goals, aimed at addressing a series of challenges including environmental issues on a global scale. This marks

a consensus among the international community in achieving global sustainable development and has become a guiding framework for governments and international organizations to work together. As a result, scholars have paid close attention to research in the field of ecological governance during this stage, and multiple related research frontiers have emerged.

Specifically, according to “Table 3”, the time from the occurrence of keyword emergence can be divided into three stages:

In the first stage, from 2010 to 2013, "resilience", "adaptive comfort", "environmental management", "science", "food security" and "fit" were the main emerging words, indicating that the forefront of ecological governance research in this

stage includes two aspects: research on ecological governance from the perspective of ecological environment restoration, such as Salomon et al.'s,[7] pointed out that understanding the restoration capacity of social ecosystems can improve people's ability to change environmental governance, achieve ecological sustainability and social justice outcomes; From the perspectives of scientific governance, adaptive governance, and ensuring food security, research on ecological environment governance strategies has been conducted. Mantyka Pringle et al.[8] have pointed out the need to link traditional and scientific knowledge to address the challenges of environmental change, such as the cumulative impact of multiple stressors on ecosystems and the services they provide. They have also proposed more effective adaptive governance practices for the restoration and sustainable development of regional ecosystems. The peak intensity of the keyword "resilience" reached 3.15, indicating that it is the most prominent research frontier in this stage.

In the second stage, from 2014 to 2017, "ecological modernization," "rivers," "multi-level governance," "livelihoods," "Australia," "stakeholder participation," and "regime shifts" became the main research frontiers. Compared with the first stage, research in this field is gradually diversifying, expanding the participants to stakeholders and even carrying out multi-level governance. Ratner B et al. [9] proposed a framework for collective action, conflict prevention, and social ecological restoration governance, linking the dynamics of local stakeholders with broader institutional and governance contexts, aiming to gain a deeper understanding of ecological governance issues in sensitive environments; Yi H et al. [10] pointed out that in the process of globalization, the interdependence of environmental resources has become a new trend. More and more countries, regions, and local governments choose to use collaborative methods to solve environmental problems, so that multi-level interactions between different entities are conducive to addressing complex environmental governance issues and achieving sustainable development. Focusing on the perspective of ecological modernization, Galli [11] proposed that ecological modernization theory is a tool to understand the complexity of climate governance at the national and sub national levels. Through case studies on energy efficiency conservation in the United States, he pointed out that mixed governance plays an important role in the implementation and long-term sustainability of

climate related policies; Research on the transformation of ecological governance system from the perspective of top-level design, such as Garmestani et al.,[12] started from the legal system of ecological governance in the United States, and points out that the existing legal system in the United States is unable to utilize the adaptability and transformative power of the law itself to enhance ecological restoration capacity, as well as to use the law to promote ecosystem adaptation and transformation.

In the third stage, from 2017 to 2020, "biodiversity conservation" was the main research frontier during this period. This is because in some parts of the world, local species richness has decreased below the threshold required to ensure the long-term maintenance of ecosystem functions and services.[13] At the same time, global initiatives such as the Convention on Biological Diversity (CBD) have failed to reverse or even slow down the overall trend of biodiversity decline.[14] Gavin M.C et al.[15] argued from the perspective of biodiversity conservation that effective ecological governance requires dynamic, diverse, and collaborative methods.

### **3.2 Hot Topic Analysis**

CiteSpace software provides four label extraction algorithms for clustering label extraction: LSI, TF \* IDF, LLR, and MI. Overall, the labels extracted by clustering using LLR algorithm are more in line with the actual situation and have fewer repetitions. Typically, a value of Muscularity Q between 0.4-0.8 indicates suitability for clustering; Silhouette is used to estimate the uncertainty involved in clustering, usually when Silhouette>0.5, the clustering is reasonable; If Silhouette>0.7, the clustering is convincing.<sup>[16]</sup> Cluster analysis was conducted on the research on ecological governance in WOS core journals, and "Figure 5" was obtained. Among them, Muscularity Q=0.4626 and Silhouette=0.7475 indicate that it is suitable for clustering and the clustering results are convincing.

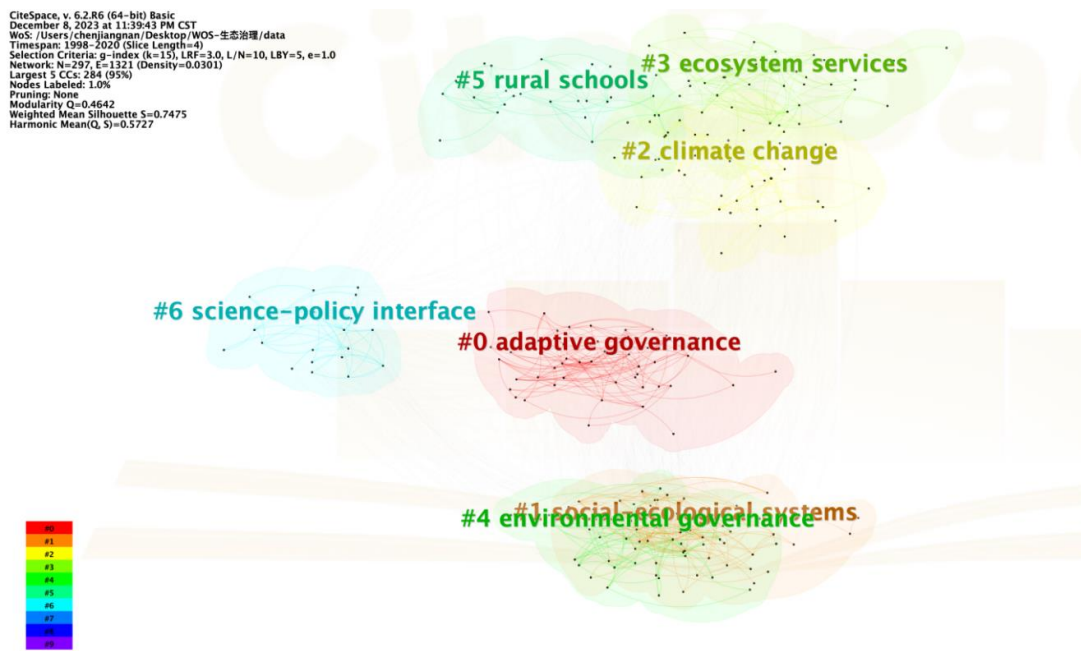


Figure 5 Keyword clustering knowledge graph of hot topics in foreign ecological governance research from 1998 to 2020.

According to “Figure 5”, the top 7 clusters of ecological governance research hotspots in WOS core journals are #0 adaptive governance, #1 social-ecological systems, #2 climate change, #3 ecosystem services, #4 environmental governance, #5 rural schools, and #6 science-policy interface. The smaller the cluster number, the more keywords are included in the cluster.

In order to further summarize the information on the hotspots of ecological governance research in WOS core journals since 1998, the six clusters in “Figure 5” and their respective top five keyword lists were exported, as shown in “Table 4”. Based on this, the researchers summarized the research hotspots and trends in the field of ecological governance, in order to clarify the knowledge system and development context of ecological governance research. According to “Table 4”, the keywords contained in each cluster are nested with each other. For example, Cluster #1 in the social ecological system includes the adaptive capacity part of Cluster #0 in adaptive governance; Adaptive management, similar nesting situations may also occur in other clusters. Based on the CiteSpace clustering view, research in the field of ecological governance can be further divided into three aspects: ecological governance model research, social ecological system governance, and ecological governance system research.



Table 4. Keyword clustering table

Cluster number	Clustering Size	Tag words	S value	Average usage year
#0	49	adaptive governance; resource stress; benefit sharing; natural resources; ecosystem services	0.67	2013
#1	46	social-ecological systems; ecosystem services; adaptive capacity; adaptive management; environmental governance	0.824	2010
#2	41	climate change; socio-ecological resilience; limiting factors; integrated water resources management; sustainable development	0.649	2016
#3	38	ecosystem services; social-ecological systems; adaptive management; adaptive capacity; environmental justice	0.723	2013
#4	32	environmental governance; adaptive governance; administrative law; global environmental governance; ocean policy	0.653	2014
#5	25	rural schools; social-ecological systems; public education; land management; adaptive governance; urban ecology	0.736	2016
#6	21	science-policy interface; policy learning; institutional design; ecological restoration; ecosystem management	0.77	2014

According to “Table 4”, the most prominent model in the field of ecological governance research is adaptive governance. It refers to an ecological governance model that coordinates resource management in the face of the complexity and uncertainty of rapid environmental changes.[17] From the keywords involved in the definition and clustering # 0, it can be seen that research on adaptive governance is mainly conducted through resource management, especially water resource management. Clark et al.[18] conducted empirical analysis on the adaptive governance methods implemented in contemporary water resource management in Chiang Mai Province, northwestern Thailand. At the same time, some scholars have also approached from the perspective of assessing the adaptability of the ecological environment, thus constructing relevant ecological governance evaluation frameworks. Adaptability refers to the ability of the ecosystem to spontaneously respond to environmental destructive changes.[19]

Scholars usually combine social ecological systems (SES) for research on ecological governance. The reason for this is that there is a close interaction and interdependence between society and ecosystems, and both are complex systems. Viewing society and ecology as a whole can better understand and manage this complexity, as well as better balance the impact of human activities on the natural environment, to ensure the sustainable use of resources, protect the health of ecosystems, and promote sustainable development.[20] As shown in “Table 4”, in

addition to appearing in Cluster # 1, it also appears in Cluster # and Cluster #5, indicating that "climate change", "ecosystem services", and "rural regulation" are hot topics in social ecological system governance research.

In the research of ecological governance system, scholars not only focus on the existing ecological environment governance system, but also pay attention to the optimization of the ecological governance system through the integration of science and policy and the design of the system; At the same time, "rural areas" and "oceans" are also hot topics for scholars to study the ecological governance system. For example, Yang et al.[21] conducted research on the implementation effects of multi-level governance, rights based, and environmental priority governance policies in rural Scotland; Yu et al.[22] analyzed the evolution characteristics of China's marine environmental governance policies, including the diversification of participants, changes from post control to pre control, the diversification of policy tools, and the expansion of governance scope. They also clarified the challenges of formulating and implementing China's marine environmental governance policies in the future.

#### 4. CONCLUSION

Using 795 literature related to ecological governance research from 1998 to 2020 in SSCI and SCI source journals included in the WOS core database as the research object, Citespace software was used to analyze the research hotspots in this

field through a combination of bibliometric and visual analysis methods. The research conclusions drawn include three aspects:

According to the analysis of the characteristics of the literature, the overall publication volume in this field has shown a steady upward trend, with clear stage characteristics. From the perspective of institutional cooperation distribution, research institutions in this field are mainly centered around Stockholm University, with California General University as the secondary core, and maintain close cooperative relationships between various institutions. Multi institutional cooperation has formed a relatively wide range of research cooperation groups, and there are also some independent research institutions. In terms of author collaboration distribution, the degree of collaboration among authors in this field is relatively high, with five main author collaboration groups formed and a core author group formed.

According to the analysis of research hotspots and frontiers, foreign research on ecological governance focuses on the study of "environmental governance", "climate change", "sustainability", "environmental protection", and related "systems" in this field; At the same time, the forefront of research in the field of ecological governance continues to enrich from three aspects: governance objectives, governance subjects, and governance perspectives, including "resilience", "adaptive management", "environmental management", "ecological modernization", "river", and "multilevel governance".

Through keyword clustering for hot topic analysis, the research topics of foreign ecological governance are nested with each other. The clustering map and keyword clustering table are further divided into three aspects: research on ecological governance models, social ecological system governance, and ecological governance system research. Among them, adaptive governance is the most important research hotspot in ecological governance model research; Climate change, ecosystem services, and rural regulation are the main research hotspots in the study of social-ecological systems; The research on ecological governance system mainly includes the study of existing systems and the exploration of optimization of existing systems, and the study of "rural" and "marine" ecological governance systems is a hot topic of concern for scholars.

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