Current Status and Future Prospects of Information Ecosystem Research in China: Postprint

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Abstract

[Purpose/Significance] This study examines the current state of information ecosystem research in China, identifies existing problems, and proposes recommendations for future research in this field, providing a reference for further advancing domestic information ecosystem research. [Method/Process] Employing bibliometric and content analysis methods, this paper analyzes domestic literature on information ecosystem research, focusing on summarizing and synthesizing its research content and characteristics. [Results/Conclusions] The results indicate that information ecosystem research in China has roughly experienced three developmental stages to date, and has currently made remarkable progress in basic issues of information ecosystems, information ecosystem evaluation, information ecosystem balance (imbalance), and information ecosystem construction and optimization, among other aspects. However, deficiencies remain in the diversity of research perspectives and methods, as well as in the breadth and depth of research content.

Full Text

Preamble

Title: Research Status and Future Prospects of Information Ecosystem Studies in China

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Abstract: [Purpose/Significance] This paper discusses the current state of information ecosystem research in China, identifies existing problems, and proposes recommendations for future research in this field, providing a reference for further advancing domestic information ecosystem studies. [Method/Process] Using bibliometric and content analysis methods, this study examines domestic literature on information ecosystems, focusing on summarizing and analyzing its research content and characteristics. [Result/Conclusion] The results indicate that information ecosystem research in China has roughly experienced three developmental stages to date, achieving notable progress in fundamental issues, evaluation, balance (imbalance), and construction/optimization of information ecosystems. However, deficiencies remain in the diversity of research perspectives and methods, as well as in the breadth and depth of research content.

Keywords: information ecology; information ecosystem; research content; research prospects

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Introduction

The information crisis of the 1960s-70s and the rapid penetration of ecology into humanities and social sciences triggered an ecological turn in information management research. Since F.W. Horton formally proposed the concept of "information ecology" in 1978 [1], information ecosystem research has gradually become a trend in developed European and American countries. In 1989, German scholar R. Capurro [2] discussed ecological balance, information pollution, and information injustice in information ecosystems in conjunction with the concept of information ecology. In 1997, American scholars T.H. Davenport and L. Prusak [3] elaborated on the meaning of information ecosystems from a micro perspective and identified factors influencing information ecology management. In 1999, B.A. Nardi and V.L. O'Day [4] summarized the composition of information ecosystems and confirmed the central position of humans within them. Subsequently, B. Detlor [5] and P.H. Jones [6] constructed models for e-commerce information ecosystems and pharmaceutical research organization information ecosystems, respectively. Since then, foreign information ecosystem research has entered a new stage, with increasing achievements in evaluation, critique, construction (improvement), and transformation based on systems theory and complexity theory.

Domestic research on information ecosystems in China began in the 1990s. Entering the 21st century, research in this field has become increasingly active. Scholars have conducted review analyses, such as Xiao Na [7], who summarized domestic research on the connotation, imbalance, and model construction of information ecosystems; Gao Yang and Li Yongxian [8], who performed quantitative analysis of domestic network information ecosystem research; Ma Jie et al. [9], who reviewed the content and characteristics of information ecosystem evaluation research in China; and Ke Jian et al. [10-11], who summarized research trends in information ecosystem structure, evaluation, evolution, and mechanisms. These achievements are useful for surveying domestic information ecosystem research progress, but most were conducted under the framework of "information ecology research reviews," some limited to certain aspects of information ecosystem research, others confined to specific time periods, making it difficult to present a complete picture of information ecosystem research in China. To address this gap, this paper re-examines and summarizes domestic information ecosystem research and prospects its future. Compared with previous studies, this paper differs in that it achieves a panoramic scan of relevant literature, extracts new insights from existing reviews, outlines the overall landscape of China's information ecosystem research, and reaches new understandings that can provide more comprehensive references for future work in this field.

1 Literature Sources and Research Overview

Based on literature reading and database coverage, the authors searched domestic publications using CNKI, Wanfang Data, and VIP as data platforms from June 10-15, 2019. Specific search rules were: Considering that information ecosystem research primarily originates from library, information, and archival science, and that some researchers equate "information ecology" with "information ecosystem," search expressions were constructed as: "subject OR title OR keywords = information ecology / archive (library) ecology" and "subject OR title OR keywords = information ecosystem / archive (library) ecosystem"; No document type restrictions or earliest inclusion dates were set, with the final inclusion date being the search date. The search results were then manually screened to remove duplicates, reports, newsletters, and other irrelevant data. To ensure objectivity and accuracy, the following processing was applied: any literature with only "information (archive/library) ecology" in the title but with sections addressing information ecosystems or reflecting information ecosystem thinking was included in the statistical analysis; for journal papers derived from master's or doctoral theses, they were counted as one with the thesis, with only the theses being statistically analyzed. After these procedures, 493 valid papers were obtained—414 journal articles, 12 doctoral dissertations, 65 master's theses, and 2 conference papers. Additionally, through the National Library catalog and Baidu Scholar, five monographs were found to contain dedicated chapters on information ecosystems: *Information Ecology and Social Sustainable Development*, *Network Social Ecology*, *Information Ecosystem Theory and Its Application*, *Digital Archives Ecosystem Research*, and *Information Ecology Theory and Application* (monographs with the same title as doctoral dissertations were counted as dissertations). These were also included in the analysis, as shown in Figure 1 [Figure 1: see original paper].

According to the literature retrieval results, domestic information ecosystem research began in 1995. Except for brief interruptions in 1997 and 1999, literature has been published every year. Among all literature, 228 items received various funding support, including 82 funded by the National Social Science Foundation, 32 by the National Natural Science Foundation, and one each by the "863 Program" and the National Soft Science Research Program, indicating that various funds have played an important role in incubating information ecosystem research achievements. Based on annual distribution, domestic information ecosystem research has roughly experienced three distinct stages: 1995-2005 can be considered the initial stage, with annual output not exceeding five items and growth not particularly evident; starting from 2006, it entered a period of rapid growth, with annual publication volume continuously rising and reaching its first peak in 2009, demonstrating that information ecosystem research has increasingly attracted academic attention; after 2009, it entered a fluctuating development period, with annual publication volume rising and falling in wave-like patterns, indicating that information ecosystem research attracted more attention during this period, but researcher interest was not particularly stable. The reasons may lie in the emergence of new topics and more in-depth and refined research content that dispersed researchers' attention.

2 Analysis of Main Research Content

A comprehensive review of the literature reveals that domestic scholars' research on information ecosystems has focused primarily on basic issues, evaluation, imbalance and regulation, and construction and optimization of information ecosystems.

2.1 Research on Basic Issues of Information Ecosystems

Basic issues typically involve the concepts, scope, and principles of information ecosystems. Domestic scholars' research on basic issues has largely revolved around definitions, composition, characteristics, and evolution.

2.1.1 Definition of Information Ecosystems Concepts are the starting point of theoretical research and the foundation for understanding phenomena. To clarify the content and scope of information ecosystems, one must first define the concept. Domestic scholars mainly understand information ecosystems from two different perspectives. One is based on the ecological dimension, using "whole" as the genus concept for definition. For example, Li Meidi [12] defined it as "an organic whole where information itself, living organisms, and their surrounding environment are interconnected and interact." Jiang Luquan [13] stated that an information ecosystem is "a unified whole formed by the continuous process of information exchange and circulation between people, human organizations, communities, and their information environment in a certain information space." Lou Ce-qun and Zhou Chengcong [14] described it as "an organic whole formed by the interconnection and interaction between information people and between information people and the information ecological environment." The other perspective is based on "systems view," interpreting it through systems science thinking. For instance, Zhang Fuxue [15] defined it as "a self-organizing system composed of information, inspiration, insight, people, and organizational capabilities." Wang Dongyan and Hou Yanxiang [16] believed that an information ecosystem is "an artificial system composed of information, people, and environment with certain self-regulating capabilities." Xie Renqiang and Ye Fulan [17] considered an information ecosystem to be "a stable, harmonious, and sustainable development system composed of four elements: information people, information, information technology, and information environment."

Evidently, due to the complexity of information ecosystems, Chinese scholars hold divergent views on their connotation and have not yet reached consensus. The holistic view, referencing the definition of ecosystems, emphasizes that information ecosystems are organic wholes while considering their formation mechanisms. The systems theory definition does not explain how information ecosystems form but emphasizes that they are artificial systems, highlighting their self-organizing and social attributes. Despite different perspectives and expressions, the two levels share common ground: Since "system" itself implies collection and structure, the systems view definition actually implicitly contains the meaning of wholeness. From the perspective of generation mechanisms and states, both definitions hold that information ecosystems are formed by information people, information, and information environment interacting according to information activity laws, rather than being simple superposition or assembly of these elements. Both recognize the dynamic relationships and mutual influences among variables within the system, thus agreeing that information ecosystems are dynamic functional units. Therefore, the concept of information ecosystem points to the organic integration and connection of people, information, and information environment, essentially representing a dynamic unity formed by information people, information, and information environment through information activities within a certain time and space.

2.1.2 Composition of Information Ecosystems Domestic discussions on the composition of information ecosystems have been extensive, with classification standards varying among scholars. Summarized, three typical viewpoints have emerged. The vast majority of scholars adhere to the "three elements" position. For example, Li Meidi [12] and Jing Jipeng [18] all decomposed the constituent elements of information ecosystems into three parts: information, information people, and information environment. Wei Fuyi and Zhou Xiuhui [19] believed that the core elements of information ecosystems are information activities, information, and information environment. Xiang Shang [20], after comparative analysis of information ecosystems and knowledge ecosystems, pointed out that information ecosystems consist of subject factors, information environmental factors, and information ecological chains. Some scholars, represented by Jiang Luquan [13] and Lou Ce-qun et al. [14], inherited the ecological classification approach, dividing information ecosystems into two major parts—information people and information ecological environment—from the perspective of subject-object duality. Another group of scholars provided more detailed decomposition of information ecosystem composition. For instance, Li Zhichang [21] categorized the components of information ecosystems into people, information, information technology, and information institutional regulations. Wang Xiwei and Liu Duo [22] identified four core elements composing information ecosystems: information people, information, information environment, and information technology. Dong Limei et al. [23] summarized the constituent elements of macro information ecosystems as information, information people, information channels, and information chains. Sun Ruiying et al. [24] believed that besides information people, information resources, and information environment, external social environment also constitutes elements of information ecosystems.

The above demonstrates that domestic scholars' understanding of information ecosystem composition is evolving from simplicity to refinement, with divergence among various viewpoints rooted in differences in abstraction levels and observation perspectives. Synthesizing scholars' perspectives reveals that information ecosystem elements are complex and multidimensional, encompassing biological components (information people) and abiotic components (information, information environment, information media, etc.). These elements are interdependent and mutually influential, collectively acting upon the evolution of information ecosystems.

2.1.3 Structure of Information Ecosystems In terms of research approaches, current analysis of information ecosystem structure is largely based on constituent elements and their arrangement logic, initially focusing on general information ecosystems. For example, Li Zhichang [21] noted that the structure of information ecosystems is mainly manifested in three aspects: temporal structure, spatial structure, and control structure, explaining the connotation of each structure. Zhang Xinming et al. [25] introduced humanistic thinking into examining information ecosystem structure, emphasizing that human information activities are the core of information ecosystems while identifying the positions of information infrastructure, information resources, information technology, and information institutional regulations within them. Combining predecessors' "three-element theory" and inter-element relationships, Xiao Jing et al. [26] constructed an information ecosystem structure diagram composed of information people, resources, and internal/external environments interacting with each other. The diagram shows that information people, information resources, and information environment respectively assume the functions of ecological nucleus, ecological base, and ecological repository in information ecosystems. Jing Jipeng et al. [27] viewed information ecosystem structure from a hierarchical relationship perspective, identifying seven levels: information individual, information population, information community, information ecosystem, regional information ecosystem, national information ecosystem, and global information ecosystem, which present an inclusive relationship from small to large.

As research progressed, scholars began to delve into specific domains such as government information ecosystems and network information ecosystems. Drawing on ecologists' analysis of ecosystem structure, Zhao Yunhe [28] divided the structure of government information ecosystems into three aspects: element structure, temporal-spatial structure, and information structure. Zhang Chao [29] categorized library information ecosystem structure into network structure and hierarchical structure, where network structure manifests as criss-crossing information ecological chains, and hierarchical structure manifests as hierarchical relationships among subsystems. Qu Jingye et al. [30] examined virtual enterprise alliance information ecosystems from a logical hierarchy perspective, pointing out that their structure includes three layers: network infrastructure, technology layer, and business layer. Chen Minghong [31] used complex adaptive systems theory to analyze network information ecosystem structure, finding that it can be divided into formal structure and evolutionary structure based on manifestation forms. Similar to Zhao Yunhe's logical thinking, Zhou Xin [32] believed that network platform information ecosystem structure manifests in three forms: spatial structure, nutritional structure, and organizational structure.

The above shows that domestic scholars have conducted multi-level and multi-directional exploration of information ecosystem structure, each depicting the reality of information ecosystems from different entry points, enabling understanding of internal organization and insight into association forms among elements. Divergent scholarly views demonstrate that, like information ecosystems themselves, their structure is full of complexity and diversity, allowing for multiple classification standards and methods. Regardless, information ecosystem structure is formed by the arrangement and combination of system elements and changes accordingly. Any understanding of information ecosystem structure cannot be separated from grasping relationships among elements and the system's temporal and spatial context.

2.1.4 Characteristics of Information Ecosystems The positioning of information production, transmission, and consumption as functions determines that information ecosystems play unique roles in economic and social development and possess typical individual characteristics. Clarifying these characteristics is significant for understanding information ecosystems. Recognizing this, Li Meidi [12] emphasized in defining information ecosystems that they are organic wholes. Subsequently, Zhang Fuxue [15] summarized that information ecosystems have characteristics of systematicity, diversity, dynamism, regionality, keystone species, and co-evolution. Li Yongkui [33], from the perspective of social attributes of information ecosystems, believed that information ecosystems belong to artificial ecosystems where almost all factors can be transformed and shaped—this is their biggest difference from biological ecosystems. Based on system composition and inter-factor relationships, Han Zijing [34] further summarized characteristics of information ecosystems, finding they possess artificiality, wholeness, hierarchy, regionality, and openness—features that enable continuous adaptation to social development and changes. Liu Zhifeng et al. [35]

used lifecycle theory to understand information ecosystems, noting that besides characteristics of temporal-spatial continuity, dynamic adaptability, and genetic variability, they also have lifecycle characteristics, with evolution divisible into four stages: startup, growth, optimization, and decline. Through comparison with biological ecosystems, Zhang Haitao et al. [36] found that information ecosystems are uniquely characterized by self-maintenance, self-regulation dynamic life features, and healthy, sustainable development. Additionally, scholars have analyzed characteristics of information ecosystems in specialized fields like libraries and network e-commerce. For instance, after examining characteristics and attributes of system elements, Xue Peng [37] noted that library information ecosystems feature complex subjects, diverse information types, and characteristics of orientation and artificiality. Chen Minghong [31] found that network information ecosystems, besides having wholeness and hierarchy, also possess dissipation, emergence, self-organization, and complex correlation. Li Beiwei et al. [38], from a complex network perspective, pointed out the topological properties of third-party e-commerce platform information ecosystems and their systemic characteristics in operation, search, and risk.

The above discussions have revealed basic attributes of different information ecosystems to some extent, reflecting Chinese scholars' overall cognition and grasp of information ecosystem characteristics. Through these discussions, we can see the multi-attribute nature of information ecosystems, and their contributions deserve recognition. However, it should be noted that, constrained by research perspectives, many researchers have not realized that the unique characteristics of information ecosystems are revealed through comparison with other systems. When exploring this issue, they have not conducted in-depth and detailed comparisons with other systems but have instead discussed it generally based on experience or relevant theories, some even considering only its ideal aspects, thus neglecting differences between general and specific attributes and failing to adequately demonstrate the uniqueness of information ecosystems.

2.1.5 Operation and Evolution of Information Ecosystems In studying information ecosystem operation, domestic scholars have devoted the most effort and writing to its mechanisms. In this regard, some researchers have adopted interdisciplinary approaches, attempting to outline elements and content of information ecosystem operation mechanisms by absorbing theories and ideas from neighboring disciplines, proposing some innovative viewpoints. For example, Zhang Yunzhong and Yang Meng [39] connected information ecosystems with the Five Elements theory, using it to clarify operation laws of information ecosystem elements and their information and energy circulation patterns, revealing causes and mechanisms of information ecosystem balance and imbalance, as well as its operation mechanisms. Zhang Yong et al. [40], from a knowledge management perspective, examined two major operation mechanisms of library information ecosystems: information-knowledge transformation mechanism and information ecological balance mechanism, finding the former manifested in knowledge proliferation, innovation, and transmission-consumption, while the latter depended on information ecological feedback and ecological co-evolution. Other researchers have conducted broader interpretations through structural analysis methods combined with operation laws and processes to achieve clearer understanding. For instance, when elaborating on digital archives ecosystem operation mechanisms, Jin Bo et al. [41] advocated examining operation mechanisms, operation modes, and operation characteristics together. To explore the essence of information ecosystems, Zhou Chengcong [42] deduced a framework for information service ecosystem operation mechanisms, subdividing it into five aspects: element function mechanism, ecological subject positioning mechanism, ecological environment optimization mechanism, information flow mechanism, and ecosystem balance mechanism, detailing each mechanism's connotation. Zhang Haitao et al. [36, 43] elaborated on operation mechanisms of enterprise information ecosystems and business website information ecosystems, showing the former consists of formation, cooperation-sharing, decision-making, coordination, competition, and circulation mechanisms, while the latter includes similar content plus mutual benefit, feedback, guidance, security, and value mechanisms.

Some scholars have focused on information ecosystem evolution. For example, Lou Ce-qun et al. [44], based on defining information ecosystem evolution concepts and characteristics, described evolution mechanisms from three aspects: fundamental driving forces, leading factors, and implementation processes, and distinguished evolution forms. Ma Jie et al. [45] noted the key role of knowledge transformation in information ecosystem evolution, discussed principles of knowledge transformation driving information ecosystem evolution, and summarized its action modes. They [46] also measured information ecosystem evolution by its ecological degree, designing methods to explore network information ecosystem evolution conditions by "comparing ecological evaluation results with system evolution indicators," and discussed evolution pathways, routes, and strategies. Using self-organization theory as an entry point, Song Tingting [47] analyzed information ecosystem evolution processes, finding they contain three mechanisms: synergy, fluctuation, and hypercycle, following laws of uncertainty, minimum threshold, and irreversibility. Focusing on rapid e-commerce development, Wang Xiwei et al. [48] discussed evolution cycles and characteristics of group-buying information ecosystems, identifying challenges and breakthrough points for domestic group-buying websites based on the evolution experience of the U.S. Groupon platform. Zhang Haitao et al. [49] focused on the evolution mechanism of business website information ecosystems, noting that their evolution is driven by internal and external forces, presenting four stages in process: gestation, germination, growth, and stability.

The essence of information ecosystem operation and evolution lies in interactions among elements and their changes over time and space. Both operation and evolution mechanisms encompass complex content. Current research in these two aspects has achieved certain depth and breadth but mostly concentrates on content and composition, with qualitative theoretical analysis predominating. There is a lack of in-depth systematic analysis supported by empirical and quantitative methods, resulting in insufficient factual basis for extracted mechanisms. Moreover, many achievements remain at the descriptive level, failing to effectively explore influencing factors and driving forces behind information ecosystem operation and evolution, with scarce discussion on generation mechanisms. Consequently, explanations of information ecosystem movement laws are not yet comprehensive.

2.2 Research on Information Ecosystem Evaluation

Complete information ecosystem evaluation covers evaluation objects, criteria, and processes, with its core being the establishment of evaluation indicators and selection of evaluation methods—thus becoming a research focus for domestic scholars.

2.2.1 Information Ecosystem Evaluation Indicators To achieve evaluation purposes, establishing a set of operable evaluation indicators is crucial. The scientific nature of evaluation indicators depends on two aspects: indicator framework construction and weight coefficient determination.

(1) Indicator Framework Construction. Currently, Chinese scholars mostly base their frameworks on information ecology theory or evaluation results from related topics, combined with their own understanding and expert opinions. Due to different evaluation purposes and objects, scholars show certain differences in indicator selection. Summarized, there are four representative frameworks. First, **system composition-based indicators** use information, information people, and information environment (including information technology) as primary indicators, with corresponding secondary and tertiary indicators. Due to minimal differences in basic elements, such indicator systems have wide applicability and have been used for evaluating information ecosystem grey correlation [50], new think tank WeChat platform ecology [51], and library comprehensive strength [52]. Second, **system attribute-based indicators** mainly aim to guide coordinated development of evaluation object elements. For example, Qi Lili [53] and Zhu Yanhong [54] proposed evaluation indicators for social security fund information systems and e-government website ecosystems from openness, cyclicality, sustainability, balance, and evolution perspectives; Wang Xiwei et al. [55] designed low-carbon portal website evaluation indicators from service, interaction, and participation aspects; Sun Yue et al. [56] established third-party mobile payment effectiveness indicators from security, convenience, universality, after-sales service, and value-added dimensions. Third, **system element and attribute-based indicators** are mainly used for network information ecosystem ecological measurement, as adopted by Ma Jie, Chen Fengjiao [57-58], and Li Yan [59], who combined current status and trends of information ecosystems to establish evaluation indicators from five aspects: information people, information, information environment, system synergy, and sustainable development potential. Fourth, **indicators based on system basics, functions, and capabilities**, such as

Li Yujie and Liu Zhifeng [60], who built an information ecosystem health evaluation system containing four primary indicators (internal elements, external environment, function mechanisms, capability performance) and 15 secondary indicators; Xue Weishuang [61], who constructed a university digital library information ecosystem evaluation framework with three primary indicators (system structure, vitality, service power) and 14 secondary indicators; and Zhang Haitao et al. [62], who designed business website information ecosystem configuration evaluation indicators with three primary indicators (system composition, performance, configuration benefits) and 32 secondary indicators. Overall, based on information ecosystem characteristics, domestic scholars have long integrated holistic and comprehensive thinking into indicator design, with all constructed systems containing multiple factors. Although no unified standard indicator model has emerged yet, and some indicators lack empirical testing, scholars' efforts have undoubtedly laid a solid foundation for advancing information ecosystem evaluation.

(2) Weight Determination. Information ecosystem evolution is influenced by multiple factors, but these factors do not play equal roles, necessitating the introduction of weight concepts to distinguish indicator importance for more realistic evaluation. Existing literature offers multiple options for determining weights. The most commonly used is the Analytic Hierarchy Process (AHP). Due to its relative maturity, operational simplicity, and combination of qualitative and quantitative advantages, it fits well with diverse and non-uniform information ecosystem evaluation indicators, thus being adopted by scholars like Ma Jie [57] and Wang Xiwei [55] who achieved good results. Different from Ma and Wang, to reflect opinions of different stakeholders on evaluation factors and effectively indicate indicator importance, Qi Lili [53] and Zhu Yanhong [54] used the fuzzy Borda number analysis method based on lattice acquisition to calculate indicator weights, showing simple operation and strong practicality. Zhang Yan et al. [63] and Zhang Haitao et al. [64] proposed using the precedence chart method to determine indicator importance, though their studies did not provide specific calculation processes or examples.

2.2.2 Information Ecosystem Evaluation Methods After constructing evaluation indicators and determining weights, domestic scholars have also explored evaluation methods. Currently, compared with weighting methods, evaluation methods are slightly more diverse. The most common is fuzzy comprehensive evaluation. Since many indicators in information ecosystem evaluation are fuzzy, transforming them into observable values requires fuzzy language—precisely the strength of fuzzy comprehensive evaluation—making it highly welcomed by scholars. Since Xiao Shuji [65] first advocated this method in 2010, Xue Weishuang [61], Qin Pingping [66], Wang Xiwei [67], and Xie Renqiang [17] have also used it for empirical evaluation of information ecosystems. Another important method is grey system analysis. Based on grey system theory and principles, this approach treats information ecosystems as "grey" objects, establishes evaluation models according to system behavioral characteristics to reveal relationships among system factors and their states, and can comprehensively consider multiple factors. Thus, it has been favored by Li Jiayu [50] and Qi Lili [53], who successively used grey correlation analysis and grey comprehensive evaluation to assess correlations between relevant factors and university library ecosystem operation and the development level of China's social security fund, achieving satisfactory results. Additionally, some scholars have proposed applying dynamic index method, comprehensive index method [64], and evaluation methods based on LWD and LOWA operators [22] to information ecosystem evaluation. Overall, due to the late start of information ecosystem evaluation research, domestic scholars have mainly adopted transplantation of methods from adjacent disciplines, with current indicator weighting and evaluation methods still relatively singular and basically subjective. Objective methods such as entropy method and principal component analysis have not been adequately attempted.

2.3 Information Ecosystem Imbalance and Remediation

Information ecosystem imbalance is an area that attracted early attention in Chinese academia, with scholars noting this issue as early as 1995. Research in this area grew rapidly thereafter but has stagnated in recent years. Similar to research on information ecosystem structure and characteristics, domestic research on imbalance has followed a path from general to specific. Scholars first discussed general information ecosystems, then focused on specific domains such as archival, library, supply chain, and network information ecosystems. Overall, domestic scholars have adopted similar approaches to information ecosystem imbalance research, typically first analyzing manifestations or causes of imbalance, then proposing corresponding prevention or remediation measures based on analysis results. Due to relatively monotonous and similar research approaches and perspectives, conclusions are largely similar. Consequently, analyses of imbalance causes in related fields, especially the design of remediation strategies, lack distinctiveness and do not address deep-level imbalance mechanisms.

The purpose of studying ecosystem imbalance is to achieve information ecosystem balance and promote healthy, sustainable development. Therefore, besides focusing on imbalance, research should also address balance. Regarding information ecosystem balance, researchers have focused on two aspects: Balance mechanisms, particularly the maintenance of balance and rebalancing after imbalance. Based on individual interests, Zhao Yunhe [68], Cheng Lin [69], and Li Jian [70] have conducted relevant discussions in their works. Balance governance. Addressing e-government information ecosystem imbalance, Li Bei [71] proposed self-organization regulation and artificial external regulation, emphasizing the importance of learning from foreign experiences. Chen Wenjuan [72] investigated and analyzed the balance status of Hubei Provincial Library's information ecosystem from macro and micro perspectives, providing corresponding optimization suggestions based on results. Song Wenji [73] identified factors influencing e-commerce information ecosystem balance and proposed measures to maintain dynamic balance from aspects of information ecological niche allocation and information people capability enhancement. Zhang Xiue et al. [74] addressed problems in current entrepreneurship information ecosystems, offering countermeasures to achieve balance from information, environment, and entrepreneurial subject perspectives.

The above research is undoubtedly meaningful for understanding information ecosystem balance and maintaining stability. However, current research mostly focuses on micro-level single systems, with less attention to macro-level regional information ecosystem balance, urban-rural information ecosystem balance, and balance between information ecosystems and other systems. Moreover, it mainly addresses theoretical topics such as balance mechanisms and values, with limited consideration of conditions and laws for balance, critical points of balance and imbalance, and measurement of balance.

2.4 Construction and Optimization of Information Ecosystems

Information ecosystem construction and optimization involve extensive scope. Scholars initially focused on foundational issues such as value objectives and core elements, later shifting focus to subdomains like enterprises, libraries, e-government, and archives management.

2.4.1 Construction of Enterprise Information Ecosystems Regarding how to promote enterprise information ecosystem construction, scholars mainly introduce relevant theories to build corresponding frameworks for practical application, or use them to examine dilemmas faced by enterprise information ecosystems and derive countermeasures. For example, integrating systems theory and information ecology theory, Zhang Xiangxian et al. [75] described construction principles of e-commerce network information ecosystems from three levels—information field, information ecological chain, and information ecological circle—and conducted empirical analysis on Taobao's information ecosystem construction. Based on information ecosystem and balance thinking, Wang Cuicui [76] identified problems in enterprise informatization such as weak awareness and lack of planning, subsequently establishing an ecological model for enterprise informatization to provide references. Ma Jie et al. [77] addressed defects in e-commerce website information classification, proposing to optimize it by focusing on catalogs, categories, and class names. Some scholars, aiming for direct theoretical application, derived wisdom from mature theories to directly provide suggestions for enterprise information ecosystem development. Inspired by system dynamics and complex systems theories, Yuan Ye et al. [78] pointed out that enterprises should adhere to benefit-ecology balance, follow system laws, establish learning organizations, and cultivate ecological awareness during information ecosystem construction. Dong Weiwei et al. [79] considered enterprise information ecosystem construction through the lens of lifecycle theory, proposing periodic construction strategies and advocating measures from five aspects including government, enterprises, and information people.

2.4.2 Construction of Library Information Ecosystems Research on library information ecosystem construction shows clear divisions, manifesting macro and micro orientations. Macro-oriented scholars focus on overall planning of library information ecosystem development. For example, Wang Meng and Xu Kaiying [80] and Wang Chunhui [81] proposed corresponding construction methods based on analysis of relevant library information ecosystem statuses. To promote library service functions, Chen Yanhong [82-83] introduced ecological regulation and environmental planning concepts into libraries, clarifying regulation objectives, principles, and approaches, as well as planning principles and steps for university library information ecosystems. Zhang Chao [29] proposed advancing university library information ecosystem construction and management from four aspects: resource ecologization, element ecologization, service evaluation ecologization, and information management ecologization.

In contrast, micro-oriented researchers focus on local aspects, seeking solutions to individual problems like resource allocation and reading services in library information ecosystems. For instance, based on analysis of reading-challenged groups' role positioning and information needs, Zhang Chunchun [84] found that the foundation for libraries to protect these groups' information rights lies in properly handling relationships among library information ecosystem elements, subsequently identifying six paths for library services to this group, including reading promotion activities and awareness cultivation. Liu Yuting and Yao Huijun [85] proposed strategies for optimizing digital library resource allocation from information resources, nodes, and transmission channels based on digital library information ecosystem nature. Zhang Haitao et al. [86] introduced the Intellectual Property (IP) concept into digital libraries, proposing construction of digital library information ecosystems based on the super-IP concept and applying it to Jilin Province digital library reconstruction.

2.4.3 Construction of Government Information Ecosystems Information technology application has greatly promoted China's e-government progress, but it still lags behind government function transformation requirements and needs accelerated construction. Regarding this, Zhang Xinli [87] believed that China's e-government information ecosystem construction should adhere to principles of wholeness, openness, collaboration, diversity, and sharing, and proposed six suggestions including introducing information experts and improving information subject literacy. Luo Wei [88] captured the ecological nature of information silos in e-government, constructing dynamic and static analysis frameworks for e-government information silo ecosystems, then demanding elimination of this phenomenon from system role positioning and concept cultivation. Combining the current status of e-government development in Nan'an District, Chongqing, Xie Jia [89] clarified three purposes for e-government information ecosystem construction: sharing, collaboration, and improving overall benefits, pointing out that optimization should proceed from information sharing, information environment, and information people. Fan Xiaochun [90] elaborated on guiding theories for e-government information ecosystem construction, conducted theoretical and empirical analysis of construction models, and proposed countermeasures for improving China's e-government information ecosystems.

2.4.4 Construction of Archival Information Ecosystems Besides the above aspects, some scholars have explored archival information ecosystem construction, such as ecological protection in archival information dissemination and optimization of archives information service ecosystems. Based on explaining the significance of information ecosystems for archival information resource co-construction and sharing, Zhang Donghua and Yao Hongye [91] analyzed problems in archival information resource co-construction and sharing within archival information ecosystems, proposing measures from archival personnel and planning management perspectives. Nie Yunxia et al. [92] viewed digital archives user information security systems as special information ecosystems, conducted modeling analysis, and proposed actions at legal, technical, management, and awareness levels to promote healthy, sustainable development. Jin Bo and Ni Daichuan [93-95] proposed corresponding propositions on cultivating resources, environment, and subjects of digital archives ecosystems.

Overall, research on information ecosystem construction in China has penetrated multiple fields. Scholars standing in different contexts have provided multiple suggestions from technical to policy levels regarding information ecosystem status and problems. These suggestions have different emphases and complement each other, pointing out directions for information ecosystem construction and development. Nevertheless, compared with rapidly evolving practical demands, existing research is still far from perfect, leaving many unresolved issues such as organic coupling among system elements and long-term development mechanisms.

3 Conclusions and Future Research Prospects

3.1 Relevant Conclusions

Through the above review and analysis, the past 20-plus years have witnessed rapid progress and numerous achievements in China's information ecosystem research under scholars' diligent exploration, presenting a research pattern emphasizing both theory and practice, macro and micro perspectives, and abstraction and concreteness. The many viewpoints and arguments, rich in insights and originality, are highly beneficial for enriching information ecology theoretical systems and promoting information ecosystem construction practice. However, compared with foreign research and the diverse, rapidly evolving situation of information ecosystems, domestic research still has blind spots and deficiencies:

3.1.1 Insufficient Diversity in Research Perspectives and Methods Considering that information ecosystems are highly interdisciplinary, rooted in information theory, ecology, and systems theory, domestic and foreign research has emphasized enhancing perspective and method diversity. Foreign research often combines information technology and communication knowledge, based on relevant theories and models, paying more attention to using information modeling, case studies, and empirical methods to explore details, effects, and adaptability of information ecosystem construction, with prominent innovation and application orientation. In contrast, domestic research mostly views information ecosystems from social science perspectives, focusing on borrowing from ecology, systems science, and information management, with weak cross-integration with computer science and statistics, resulting in relatively few achievements from technical and mathematical logic perspectives. Methodologically, more deductive reasoning, systems analysis, and causal analysis are used, preferring to derive new theories or solutions from existing theories, while practical investigation, statistical analysis, synthesis, and structural equation modeling requiring experimental or data support are very limited, constraining the originality and progress of information ecosystem research.

3.1.2 Narrow and Scattered Research Content Currently, most Chinese information ecosystem researchers come from university teaching and research departments and libraries. Constrained by authors' disciplinary and professional backgrounds, existing research mainly targets information ecosystems in libraries, internet, enterprises, and government, with less involvement in education, healthcare, public opinion, and other fields. In terms of content, besides focusing on previously mentioned themes, other issues, especially micro-level topics, lack adequate inquiry. This contrasts with foreign research where subjects come from broader sources (including university departments, libraries, enterprises) and have broader vision (covering government, medicine, health, business, education, environment, etc.). Although domestic research output is considerable, numerous topics only have sporadic "scattered discussions," with literature distributed in scattershot fashion and low content concentration. Meanwhile, some repetitive research on composition, imbalance, and evaluation has led to similar viewpoints among different researchers, lacking unique insights.

3.1.3 Research Depth Needs Improvement Constrained by thin research methods and scattered themes, besides a few topics like information ecosystem operation mechanisms and digital archives ecosystems, exploration of most themes remains at initial stages, only staying at the phenomenological level of logical deduction and explanation of concepts, structures, mechanisms, and models. There has been no good integration of multidisciplinary theories, methods, and tools with information ecosystems to fully explore and capture deep-level problems hidden behind phenomena. Consequently, sustained attention to specific information ecosystem topics or types through longitudinal, specialized series of articles or monographs is still rare, making the entire information ecosystem research appear to lack sufficient depth.

3.2 Future Research Prospects

The above problems reflect that domestic information ecosystem research maturity still requires time, but contains broad development prospects. To form a complete theoretical framework soon, future research should focus on the multi-attribute characteristics of information ecosystems, optimize team composition (attracting more practical and technical personnel), reasonably integrate multidisciplinary theories and methods, and work on both horizontal expansion and vertical extension: on one hand, actively deepen disciplinary exchanges, strengthen dialogue and interaction with synergetics, communication studies, systems theory, cybernetics, and computer science, fully borrowing beneficial results to enrich research perspectives; simultaneously strengthen application of actual investigation, modeling simulation, mathematical statistics, grounded theory, and comparative methods to promote methodological diversification and standardization. On the other hand, strengthen balance between theoretical and applied, general and specific research content, pay attention to differences and connections among various levels and types of information ecosystems, continue consolidating basic theory while embedding research in broad and profound information practice, targeting more information ecosystems (e.g., medical, environmental, health, public opinion), adhering to classified in-depth approaches, and conducting empirical series explorations for various information ecosystems. Therefore, the following content should be prioritized:

3.2.1 Research on Information Ecosystem Types and Characteristics That information ecosystems can become independent research objects shows they are not simple mappings of ecosystem concepts in the information field but have unique meanings. Moreover, information ecosystems have hierarchy and diversity, with similarities and differences among various types. This determines that their characteristics cannot be completely identical and cannot be generally summarized by intuition or experience. Instead, they should be accurately judged based on investigation and comparison according to facts. Therefore, future research should, on the basis of extensive and in-depth investigation, conduct detailed classification of information ecosystems, then compare various classified ecosystems with each other or with other systems. Through all-round, multi-level comparisons among similar and different systems, commonalities and differences should be summarized to truly reveal their unique connotations and characteristics.

3.2.2 Research on Information Ecosystem Structure-Function Relationships Scholars have simulated and explained information ecosystem structure through various methods, but questions remain: What is the complete structure of information ecosystems and its change mechanism? What is its relationship with information ecosystem functions (benefits)? How does structure affect operation and effectiveness? What structure is most stable and conducive to function performance? What are the key factors supporting information ecosystem structure? Answering these questions is key to understanding structure-function relationships. Therefore, future research should connect information ecosystem structure and function, exploring their association mechanisms to lay foundations for optimizing system organization and effectiveness.

3.2.3 Research on Information Ecosystem Dynamic Mechanisms It is well known that information ecosystem generation and evolution are subject to combined effects of multiple internal and external forces, with competition and cooperation among these forces constituting the original driving force for system evolution and development. Due to different natures, directions, and focus points, various forces play distinctly different roles in information ecosystem evolution, some even reversing under different conditions, causing significant differences in formation paths, operation, and evolution. Existing research has noted mutual influences among composition factors and their effects on evolution, but has not provided clear answers to questions like: What is the magnitude of various factors' effects on generation and evolution? Which driving factors are more needed at different lifecycle stages? Under what circumstances and with what intensity should factors act to best ensure stability and development? Which system is more efficient and sustainable when dominated by different forces? Are current driving forces sufficient for various systems? Answering these would help close the distance to dynamic mechanisms and provide stronger guarantees for balanced evolution.

3.2.4 Research on Information Ecosystem Coupling Mechanisms Information ecosystem elements are complex and diverse, coexisting and conflicting with each other, while system health and function ultimately depend on benign interaction and coupling synergy among elements. Existing research has noted the external form of information ecosystems as systems but has somewhat neglected coupling mechanisms. Consequently, many studies still use reductionist approaches to decompose elements for individual analysis. While this 精细化 operation helps examine internal aspects, it inadvertently overlooks coupling mechanisms, weakening systemic wholeness. How exactly do various elements link and couple? What characteristics and laws are embedded? To what degree of coordination can system functions and benefits be maximized? How can coupling be elevated from low to high levels and maintained optimally? These questions must be clarified to ensure orderly stability and efficient operation.

3.2.5 Research on Information Ecosystem Evaluation With diverse types and complex structures, information ecosystem evaluation involves multiple levels and dimensions. Existing research has made initial progress in system health, ecological degree, and benefits, but mostly concentrates on indicators and methods, with static evaluation predominating and scarce involvement in basic theories (subjects, models, criteria), implementation processes, and strategies. Future research should prioritize enriching evaluation methods and dimensions. While developing more objective methods, evaluation should be guided by promoting system effectiveness and sustainability, incorporating complexity evaluation, stability (fragility) evaluation, risk (security) evaluation, integrity evaluation, competitiveness evaluation, and development level evaluation into research scope. Special attention should be paid to indicator applicability, with continuous tracking of research objects to conduct in-depth summarization and verification through long-term monitoring and data accumulation for more comprehensive conclusions. Additionally, the macro-framework of information ecosystem evaluation should be improved, exploring evaluation subjects, standards, and result application.

3.2.6 Research on Information Ecosystem Governance The purpose of exploring information ecosystems is to clarify their essence and laws to improve them for better service to economic and social development. Currently, new-generation information technology represented by "big data, IoT, mobile internet, AI, and cloud computing" is developing rapidly, accelerating inter-industry connection and integration, making information ecosystem environments more open and turbulent, deconstructing and reshaping information ecosystem appearances with unprecedented intensity, posing severe challenges to information management. In this situation, information ecosystem research must closely monitor impacts of new technologies, judge possible evolution directions and emerging issues under new technological conditions, incorporate construction and management of various information ecosystems into national governance modernization policy tracks, integrate governance theories and successful foreign cases, and study governance principles, policies, laws, ethics, and pathways to propose frameworks responsive to technological changes and practical needs, promoting information ecosystem metabolism and transformation.

References

[1] HORTON F W. Information ecology[J]. Journal of systems management, 1978, 29(9): 32-36.
[2] Zhou Qingshan, Li Hanying, Zhu Jianrong, et al. Overview of information ecology research and preliminary exploration of terminology definition[J]. Library and Information, 2006(6): 24-29.
[3] DAVENPORT T H, PRUSAK L. Information ecology: mastering the information and knowledge environment[M]. New York: Oxford University Press, 1997: 28-45.
[4] NARDI B A, O'DAY V L. Information ecologies: using technology with heart[M]. Massachusetts: MIT Press, 1999: 55-82.
[5] DATLOR B. The influence of information ecology on e-commerce initiatives[J]. Internet Research, 2001, 11(4): 286-295.
[6] JONES P H. Information practices and cognitive artifacts in scientific research[J]. Cogntechwork, 2005(7): 88-100.
[7] Xiao Na. Review of domestic information ecology theoretical research[J]. Information Science, 2011, 29(7): 1114-1120.
[8] Gao Yang, Li Yongxian. Review of domestic network information ecosystem research[J]. Library Science Research, 2014(10): 12-17.

[9] Ma Jie, Hu Mo, Li Dan. Review of domestic information ecosystem evaluation research[J]. Information Science, 2015, 33(6): 143-149, 161.
[10] Ke Jian, Hu Yanglinxiao. Review of domestic information ecology research[J]. Information Science, 2016, 34(10): 163-168.
[11] Ke Jian, Peng Hanqi, Huang Wenqian. Review of domestic information ecology research[J]. Information Exploration, 2019(7): 119-127.
[12] Li Meidi. Analysis of information ecosystems[J]. Journal of Intelligence, 1998, 17(4): 3-5.
[13] Jiang Luquan. Information ecology and social sustainable development[M]. Beijing: Beijing Library Press, 2003: 140, 143-146.
[14] Lou Cequn, Zhou Chengcong. Information ecological chain: concept, nature, and types[J]. Library and Information Service, 2007, 51(9): 29-32.
[15] Zhang Fuxue. Preliminary study on information ecology[J]. Information Science, 2002, 20(1): 31-34.
[16] Wang Dongyan, Hou Yanxiang. Analysis of root causes and countermeasures for information ecological imbalance[J]. Information Science, 2003, 21(6): 572-575, 583.
[17] Xie Renqiang, Ye Fulan. Research on B2C e-commerce APP information ecology[J]. Journal of Beijing University of Posts and Telecommunications (Social Sciences Edition), 2018, 20(1): 11-16, 42.
[18] Jing Jipeng. Future prospects of information ecology theoretical research[J]. Library and Information Service, 2009, 53(4): 5-7.
[19] Wei Fuyi, Zhou Xiuhui. Research on core issues of information ecosystem construction[J]. Library Work and Study, 2010(7): 6-8.
[20] Xiang Shang. Comparative study of information ecosystems and knowledge ecosystems[J]. Information Theory and Practice, 2011, 34(6): 123-125.
[21] Li Zhichang. On social information ecology issues[J]. Journal of Yunnan Provincial Committee Party School of CPC, 2004, 5(5): 42-44.
[22] Wang Xiwei, Liu Duo. Research on elements and evaluation indicators of enterprise information ecosystems[J]. Library and Information Service, 2010, 54(16): 22-25.
[23] Dong Limei, Song Wei, Dai Lei. Research on concept, composition, and function of macro information ecosystems[J]. Information Science, 2013, 32(8): 27-31.
[24] Sun Ruiying, Jiang Yongfu, Liu Dandan. Research on information alienation from an ecological perspective[J]. Information Theory and Practice, 2011, 34(4): 5-9.
[25] Zhang Xinming, Wang Zhen, Zhang Hongyan. Research on people-oriented information ecosystem construction[J]. Information Theory and Practice, 2007, 30(4): 531-533.
[26] Xiao Jing, Li Beiwei, Wei Changlong, et al. Structure and optimization of information ecosystems[J]. Information Science, 2013, 31(8): 10-14.
[27] Jing Jipeng, Zhang Xiangxian. Information ecology theory and application[M]. Beijing: Science Press, 2017: 45.
[28] Zhao Yunhe. Research on government information ecosystem theory and its application[D]. Wuhan: Central China Normal University, 2011: 27-30.

[29] Zhang Chao. Research on optimization of university library information ecosystem[D]. Changchun: Jilin University, 2013: 28-55.
[30] Qu Jingye, Zhang Xiangxian, Sun Xiaoyu. Research on virtual enterprise alliance information ecosystem construction[J]. Information Science, 2015, 33(5): 28-32.
[31] Chen Minghong. Analysis of network information ecosystem based on CAS theory[J]. Information Science, 2012, 30(7): 1065-1070.
[32] Zhou Xin. Research on network platform construction mechanism and operation efficiency evaluation from information ecology perspective[D]. Changchun: Jilin University, 2016: 86-98.
[33] Li Yongkui. Research on information ecology issues in engineering project management[J]. Project Management Technology, 2004(8): 33-35.
[34] Han Zijing. Preliminary exploration of information ecosystems[J]. Library and Information Service, 2008, 52(S2): 230-234.
[35] Liu Zhifeng, Zhang Zhiyu, Wang Shilei. Research on information ecosystem from lifecycle theory perspective[J]. Science and Technology Management Research, 2009, 29(4): 133-135.
[36] Zhang Haitao, Yan Yiwen, Leng Xiaoyan. Logical model and operation mechanism of enterprise information ecosystems[J]. Information Theory and Practice, 2010, 33(4): 6-9.
[37] Xue Peng. Research on evaluation of university library information ecosystem[D]. Jinan: Shandong University, 2013: 24.
[38] Li Beiwei, Zhang Xinqi, Wang Ya, et al. Analysis of third-party e-commerce platform information ecosystem characteristics—from a complex network perspective[J]. Information Science, 2014, 32(7): 78-82.
[39] Zhang Yunzhong, Yang Meng. Research on information ecosystem operation mechanism based on Five Elements theory[J]. Library and Information Service, 2010, 54(22): 61-65.
[40] Zhang Yong, Xu Kaiying, Wang Meng. Research on information ecosystem operation mechanism based on knowledge services[J]. Study & Exploration, 2011(4): 183-185.
[41] Jin Bo, Ding Huadong, Ni Daichuan, et al. Research on digital archives ecosystem[M]. Beijing: Learning Press, 2014: 243-265.
[42] Zhou Chengcong. Research on operation and optimization mechanisms of information service ecosystem[D]. Wuhan: Central China Normal University, 2011: 25-101.
[43] Zhang Haitao, Sun Xueshuai, Zhang Li, et al. Construction and operation mechanism of business website information ecosystem[J]. Information Theory and Practice, 2012, 35(8): 1-6.
[44] Lou Cequn, Yang Xiaoxi, Wang Weibo. Preliminary exploration of information ecosystem evolution[J]. Library and Information Service, 2009, 53(18): 26-29.
[45] Ma Jie, Leng Xiaoyan, Zhang Xiangxian. Research on knowledge transformation driving information ecosystem evolution[J]. Information Theory and Practice, 2010, 33(4): 14-17.
[46] Ma Jie, Hu Mo, Zhang Haitao. Research on network information ecosys-

tem evolution based on ecological degree measurement[J]. Information and Documentation Services, 2015(4): 6-12.
[47] Song Tingting. Research on self-organization evolution process of information ecosystem[D]. Harbin: Heilongjiang University, 2014: 13-49.
[48] Wang Xiwei, Wang Weiwei, Ye Naixi, et al. Evolution and case study of information ecosystem in online group buying[J]. Information Science, 2013, 31(8): 125-131.
[49] Zhang Haitao, Wang Dan, Zhang Lianfeng, et al. Evolution mechanism of business website information ecosystem—from value chain perspective[J]. Library and Information Service, 2015, 59(15): 80-86.
[50] Li Jiayu, Li Jianfei. Empirical research on grey correlation of information ecosystem[J]. Information Theory and Practice, 2011, 34(7): 85-88.
[51] Wang Xiwei, Wang Nan'axue, Zhang Liu, et al. Ecological evaluation and empirical study of new think tank WeChat platform—from information ecology perspective[J]. Library and Information Service, 2017, 61(15): 51-59.
[52] Zheng Rong, Wang Jie. Research on evaluation and countermeasures of university library comprehensive strength from information ecology perspective[J]. Information Science, 2018, 36(8): 39-45, 52.
[53] Qi Lili. Research on social security fund information system[D]. Tianjin: Tianjin University, 2010: 104-126.
[54] Zhu Yanhong, Qi Lili. Research on e-government network information ecology evaluation in China[J]. Modern Intelligence, 2014, 34(6): 12-17.
[55] Wang Xiwei, Guo Yu, Wei Weiwei, et al. Ecological evaluation and empirical study of portal websites—taking low-carbon portals as example[J]. Library and Information Service, 2014, 58(19): 111-117.
[56] Sun Yue, Zhang Xiangxian, Guo Shunli. Research on third-party mobile payment effectiveness evaluation from information ecology perspective[J]. Information Science, 2015, 33(2): 35-40.
[57] Ma Jie, Wei Aoxi, Wang Yandong. Measurement model for ecological degree of network information ecosystem[J]. Information Science, 2014, 32(7): 78-82.
[58] Chen Fengjiao, Yang Xue, Ma Jie. Measurement, defects analysis, and optimization of government network platform information ecology[J]. Library and Information Service, 2014, 58(15): 6-13, 27.
[59] Li Yan, Hu Mo, Wang Yandong. Research on public digital library information ecology evaluation[J]. Library and Information Service, 2014, 58(15): 35-41.
[60] Li Yujie, Liu Zhifeng. Research on connotation, nature, and evaluation system of information ecosystem health[J]. Science and Technology Management Research, 2009, 29(6): 263-266.
[61] Xue Weishuang. Research on evaluation system construction of university digital library information ecosystem[D]. Qufu: Qufu Normal University, 2012: 17-23.
[62] Zhang Haitao, Zhang Li, Zhang Lianfeng, et al. Configuration and evaluation of business website information ecosystem[J]. Information Theory and Practice, 2012, 35(8): 12-16, 11.

[63] Zhang Yan, Zhang Li, Sun Xueshuai, et al. Research on enterprise information ecosystem evaluation[J]. Library and Information Service, 2012, 56(12): 96-100.
[64] Zhang Haitao, Zhang Lianfeng, Sun Xueshuai, et al. Business benefit evaluation of business website information ecosystem[J]. Information Theory and Practice, 2012, 35(8): 1-6.
[65] Xiao Shuji. Research on evaluation indicator system construction of enterprise information ecosystem[D]. Changchun: Jilin University, 2010: 53-54.
[66] Qin Pingping. Research on knowledge sharing evaluation indicator system based on enterprise information ecosystem[D]. Tianjin: Tianjin Normal University, 2012: 52-57.
[67] Wang Xiwei, Yang Mengqing, Xing Yunfei. Ecological evaluation indicator construction and empirical study of mobile terminal portal websites—from information ecology perspective[J]. Information Theory and Practice, 2015, 38(6): 14-18.
[68] Zhao Yunhe, Lou Cequn, Qi Fen. Balance mechanism of information ecosystem[J]. Library and Information Service, 2009, 53(18): 22-25.
[69] Cheng Lin, Zou Zhengyu. Research on mechanism of information field promoting educational information ecosystem balance[J]. Information Science, 2011, 29(5): 658-661.
[70] Li Jian, Ma Jie. Research on regulatory mechanism of information diversity on social network ecosystem balance[J]. Information Science, 2015, 33(8): 39-43, 71.
[71] Li Bei. Construction and balance of e-government information ecosystem[D]. Suzhou: Soochow University, 2011: 33-53.
[72] Chen Wenjuan. Research on balance of Hubei library information ecosystem[D]. Wuhan: Central China Normal University, 2012: 12-53.
[73] Song Wenji. Research on dynamic balance of e-commerce information ecosystem[D]. Wuhan: Central China Normal University, 2016: 16-24.
[74] Zhang Xiue, Xu Xuejiao, Mao Gang. Research on implementation path of entrepreneurship information ecological balance[J]. Ecological Economy, 2017, 33(12): 66-71.
[75] Zhang Xiangxian, Zhang Xu, Zheng Xu. Research on construction of e-commerce information ecosystem[J]. Library and Information Service, 2010, 54(10): 20-24.
[76] Wang Cuicui. Research on enterprise informatization from information ecology perspective[D]. Jinan: Shandong University, 2009: 19-66.
[77] Ma Jie, Yan Ming, Jing Jipeng. Research on e-commerce website information classification optimization from information ecology perspective[J]. Information Science, 2012, 30(3): 360-364.
[78] Yuan Ye, Wang Ping, Zhang Weidong. Theoretical foundation and implementation strategy of enterprise information ecosystem construction[J]. Journal of Changchun University of Science and Technology (Social Sciences Edition), 2009, 22(5): 756-758.
[79] Dong Weiwei, Li Beiwei, Jing Jipeng. Research on enterprise information ecosystem construction strategy and countermeasures[J]. Information Science,

2011, 29(2): 211-215.
[80] Wang Meng, Xu Kaiying. Construction of library information ecosystem based on knowledge services[J]. Library Science Research, 2011(17): 43-47.
[81] Wang Chunhui. Research on development strategy of Chongqing tertiary hospital libraries from information ecosystem perspective[D]. Chongqing: Chongqing Medical University, 2017: 16-37.
[82] Chen Yanhong. Ecological regulation of library information system[J]. Library Science Journal, 2012, 34(8): 37-38.
[83] Chen Yanhong. Research on ecological planning of university library information system[J]. Information Exploration, 2015(7): 116-118.
[84] Zhang Chunchun. Research on service path for reading-challenged groups based on library information ecosystem[J]. Library, 2014(5): 81-83.
[85] Liu Yuting, Yao Huijun. Optimal allocation of digital library resources from information ecosystem perspective[J]. Shanxi Archives, 2018(3): 123-125.
[86] Zhang Haitao, Zhang Nianxiang, Cui Yang, et al. Construction of digital library ecosystem based on super IP[J]. Information Science, 2018, 36(9): 22-26, 176.
[87] Zhang Xinli. Research on China's e-government information ecosystem construction[D]. Baoding: Hebei University, 2011: 26-31.
[88] Luo Wei. New exploration of e-government "information silos"—from information ecology perspective[J]. Information Science, 2013, 31(1): 31-35.
[89] Xie Jia. Research on construction and management strategies of e-government information ecosystem[D]. Chongqing: Southwest University, 2013: 7-30.
[90] Fan Xiaochun. Theoretical and empirical research on e-government information ecosystem construction model[J]. Information Science, 2014, 32(10): 86-92.
[91] Zhang Donghua, Yao Hongye. Archives information resource co-construction and sharing based on information ecosystem[J]. Archives, 2011(1): 7-9.
[92] Nie Yunxia, Zhang Jiaxin, Gan Min. Research on digital archives user information security system construction from information ecology perspective[J]. Archives Science Study, 2017(1): 66-72.
[93] Jin Bo, Ni Daichuan. Analysis of digital archives ecosystem resources cultivation[J]. Archives Science Bulletin, 2017(2): 49-53.
[94] Ni Daichuan, Jin Bo. Research on survival environment cultivation of digital archives ecosystem[J]. Archives Science Bulletin, 2017(4): 73-77.
[95] Ni Daichuan. Research on subject cultivation of digital archives ecosystem[J]. Archives Science Study, 2018(3): 89-94.

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