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Research Progress and Trend Analysis of Eco-Museums from a CiteSpace Perspective

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Abstract:

As an important approach to achieving sustainable development, eco-museums have attracted widespread attention in recent years. This study employs CiteSpace to conduct a visual analysis of eco-museum research literature from 2011 to 2025 in the Web of Science Core Collection, unveiling the research progress and development trends in this field.The findings indicate that eco-museum research has gradually evolved from an initial focus on cultural heritage preservation into a broader interdisciplinary framework, incorporating environmental sustainability, community engagement, and digital innovation.This study contributes to a deeper understanding of the current state and trends of eco-museums, identifies gaps in existing research, and provides directional guidance for future studies. It aims to facilitate further exploration of eco-museums in areas such as policy-making, heritage conservation, community governance, and ecological sustainability.

Keywords: Eco-Museums, trend analysis, CiteSpace

1. INTRODUCTION

The concept of the eco-museum first appeared at the ninth International Council of Museums (ICOM) conference in August 1971, introduced by French museologists Georges Henri Rivière and Hugues de Varine. Developed in the context of the deepening awareness of cultural heritage preservation, eco-museums aim to provide a holistic approach to the protection and dynamic presentation of the natural, cultural, and social environments of specific regions. Its core philosophy, "Museum Without Walls," emphasizes that museums are not merely repositories for artifacts and exhibitions but also platforms for interaction between people, nature, culture, and society. Eco-museums are community-centered, emphasizing local participation and cultural identity, ensuring that heritage is preserved through holistic conservation, in-situ display, and active transmission, thereby revitalizing cultural heritage.

Since 1999, scholars have conducted extensive research on the concept of eco-museums. Peter Davis, in his book Eco-museum: A Sense of Place (1999), argued that eco-museums are not just a type of museum but a concept that emphasizes the close relationship between people, the environment, culture, and communities [1]. In 2008, Elizabeth Crooke analyzed the relationship between museums, communities, and heritage from the perspectives of museology and heritage studies [2]. In 2011, Robin Boast pointed out that although museums attempt to collaborate with Indigenous communities, their interactions within museum spaces are not entirely equal [3]. Andrea Witcomb (2015) further explored power dynamics in knowledge production, asserting that museums not only influence communities but also serve as platforms for Indigenous empowerment and dialogue [4]. In 2017, Michelle L. Stefano, based on her study of the Rapper Dance tradition in Northeast England, proposed the concept of "natural-occurring eco-museums," suggesting that the spontaneous preservation of intangible cultural heritage (ICH) can transcend the geographical and ethnic limitations of eco-museums [5].

As an advanced citation visualization tool, CiteSpace can reveal knowledge structures and evolutionary trends in scientific literature. Its application not only helps to provide a macro perspective on the overall development of eco-museum research but also assists in identifying key studies and research hotspots in this field. This study utilizes CiteSpace to analyze the research progress and trends in eco-museum studies, promoting the sustainable development of eco-museums and providing guidance for future research and practice

2. RESEARCH METHODOLOGY

This study employs CiteSpace, a scientific mapping method, to analyze the research progress and trends in eco-museum Scientific mapping is defined as a "general process for domain analysis and visualization" [6], aiming to uncover the structure of a given scientific field. This method, through visualization techniques, helps identify key patterns and trends vast amounts of literature and bibliographic data, enabling researchers to detect relationships between studies that traditional methods may not easily reveal.Among these approaches, bibliometric analysis focuses on the literature itself, while analysis integrates bibliometric tools and data to provide a more comprehensive evaluation of publications, identifying trends and key insights within a research domain [7].Accordingly, this study applies scientometricanalysis techniques, which

primarily consist of the following phases: selection of scientific mapping tools, data collection and analysis, visualization, and the presentation, interpretation, and discussion of results.

2.1 Selection of Scientific Mapping Tools

This study employs CiteSpace, a visualization analysis software, to identify the evolution and trends within the field of scientific research over time and to present them visually [8]. As a widely used tool in knowledge mapping, CiteSpace enables the representation of the macro-structure and future trajectory of the eco-museum research field through time-series dynamic graphs. This study applies CiteSpace to analyze the theoretical structure, evolutionary paths, research hotspots, and development trends of eco-museum research from 2011 to 2025, conducting multi-dimensional dynamic network analysis to reveal the development landscape and research frontiers of this field.

2.2 Data Collection

To ensure the authority and relevance of the research data, this study selected the Web of Science Core Collection as the data source when investigating research trends in the field of eco-museums. Using "eco-museum" as the theme keyword, an advanced search was conducted covering the period 2011 to 2024. The study included literature classified as "Article," "Review," and "Conference Papers", while research directions were restricted to "Construction Building Technology" and "Architecture", and only English-language publications were considered. These criteria ensured accuracy and an international perspective in the study.

After deduplication, ranking, and rigorous selection, a total of 234 valid documents were obtained as the final dataset for analysis. Utilizing CiteSpace, a visual analysis was conducted on these documents to uncover the knowledge structure, research hotspots, and evolutionary trends within the eco-museum domain, thereby providing clear guidance for future research directions.

3. CITATION ANALYSIS RESULTS

3.1 Keyword Knowledge Mapping

3.1.1 Keyword Co-occurrence Network.

Keywords reflect the main themes and core ideas of publications, and analyzing them helps to identify the key focus areas of eco-museum research. In this study, keywords from 2011 to 2024 were analyzed by importing Web of Science (WoS) data into CiteSpace. In the generated network, keywords serve as nodes, with one year as the time slice, producing a keyword co-occurrence network for eco-museum research (Figure 1).

The network density index in the mapping reflects the degree of connectivity between nodes. A value closer to 1 indicates a higher level of connection between keywords. In this study, the network density is 0.0166 (Density = 0.0166), indicating a relatively low density, suggesting that high-frequency keywords are not strongly connected and that research in this area remains relatively dispersed.

The betweenness centrality of a keyword in the network reflects its importance in linking other keywords. Generally, a keyword with a centrality value above 0.1 is considered important. Among the most frequently occurring keywords, seven had a centrality value greater than 0.1, with “eco-museum,” “protection,” and “cultural heritage conservation” ranking highest. This indicates that during this period, eco-museum research was primarily focused on cultural heritage conservation.

However, some keywords, such as “ethnic culture,” “sustainable development,” and “rural revitalization”, had a centrality value of 0, suggesting that they are still in the early stages of research with relatively low influence.

After removing disciplinary terms and common words, a table of research hotspots (Table 1) was compiled. Among the top 20 high-frequency keywords, "cultural heritage" appeared most frequently, followed by "evolution". In terms of centrality, the highest-ranked keywords were “conservation” (0.32), “climate change” (0.26), and “museum” (0.22).

These findings indicate that eco-museum research is not only focused on cultural heritage conservation but is also closely related to climate change and museum development. This suggests a growing interdisciplinary and multi-dimensional trend in eco-museum studies, with increasing attention on environmental factors, conservation strategies, and the evolving role of museums.

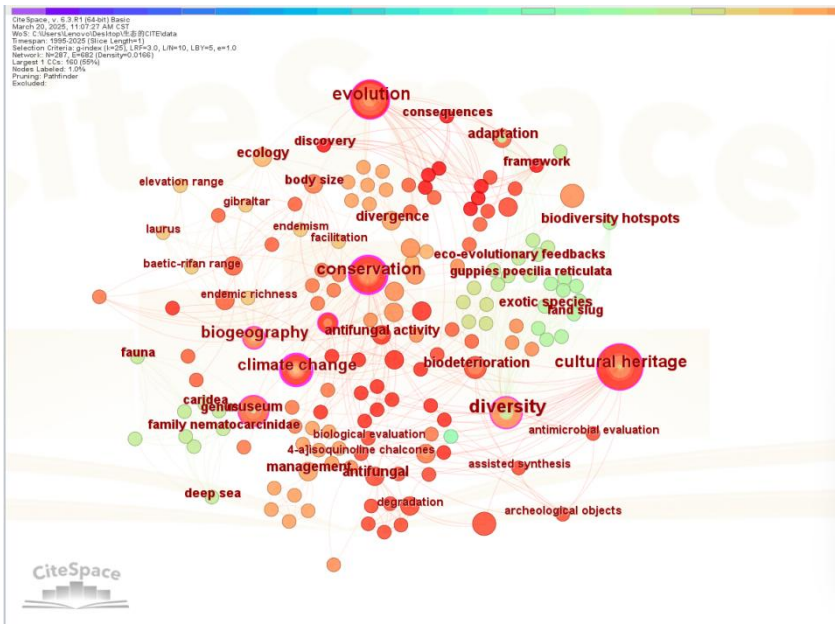

Figure 1.The high frequency keywords of papers

Table 1.Keyword Statistics Table (Top 20 in Frequency Ranking)

No	Keywords	Freq	Centrality	No	Keywords	Freq	Centrality
1	cultural heritage	22	0.21	11	biodiversity	8	0.05
2	evolution	18	0.16	12	paper	7	0.07
3	conservation	16	0.32	13	history	7	0.02
4	diversity	15	0.15	14	heritage textiles	6	0.01
5	climate change	14	0.26	15	tensile strength	5	0.04
6	museum	13	0.22	16	antifungal	4	0.04
7	design	11	0	17	body size	4	0.03
8	behavior	10	0.15	18	patterns	3	0
9	biogeography	9	0.13	19	antifungal activity	2	0.02
10	biodeterioration	9	0.02	20	temperature	2	0.01

3.1.2 Knowledge Mapping Network Clustering Analysis.

Based on the keyword co-occurrence network, a keyword clustering analysis was conducted using the LLR algorithm, generating the eco-museum research keyword clustering map (Figure 2). The network modularity evaluation index Q-value is 0.8591 (Q > 0.3), and the average silhouette value S is 0.9008 (S > 0.5), indicating that the clustering structure is reasonable and effective. Different clusters represent distinct knowledge domains, while identical clusters indicate research in the same field. The clusters generated in CiteSpace show that the largest cluster is labeled #0, while the smallest is #9. The top 10 clusters are listed, all with silhouette values > 0.8, demonstrating that the results are significant and reliable. The following section provides a detailed analysis of the top three keyword co-occurrence clusters.

Cluster #0, titled "Ancient Egyptian Mummy Cartonnage Egypt," includes 23 representative documents. In recent years, this topic has primarily focused on the study of cartonnage in Ancient Egyptian mummies within the context of eco-museums, covering material composition analysis, conservation techniques, and cultural significance. The research reflects the interdisciplinary application of eco-museum principles in cultural heritage conservation, emphasizing the use of scientific

methods to preserve and transmit historical artifacts while also exploring their relationship with local communities and ecological environments. This research trend suggests that eco-museum studies are not only concerned with heritage preservation but also with its social value and sustainable utilization.

Cluster #1, titled "Mission," includes 21 representative documents. This cluster mainly discusses the practice and development of eco-museums in different regions, particularly focusing on the core concept of "mission." It explores the functional positioning of eco-museums, their cultural preservation goals, and their impact on communities. The research examines how eco-museums fulfill their responsibilities in heritage conservation, educational outreach, and sustainable development through living cultural exhibitions, community engagement, and environmental conservation. Additionally, this cluster considers the adaptability of eco-museums on a global scale, exploring how their missions vary across different cultural and social contexts.

Cluster #2, titled "Human-Introduced," examines the impact of human activities on eco-museums and their conservation objectives, covering areas such as cultural heritage protection, environmental changes, human intervention, and sustainable management. This cluster includes 15 representative documents, focusing on the role of human influence in shaping, altering, or even threatening cultural and ecological systems in the process of eco-museum construction and development. As eco-museum research continues to deepen, balancing human activities, cultural heritage preservation, and ecological sustainability has become a key issue in the field.

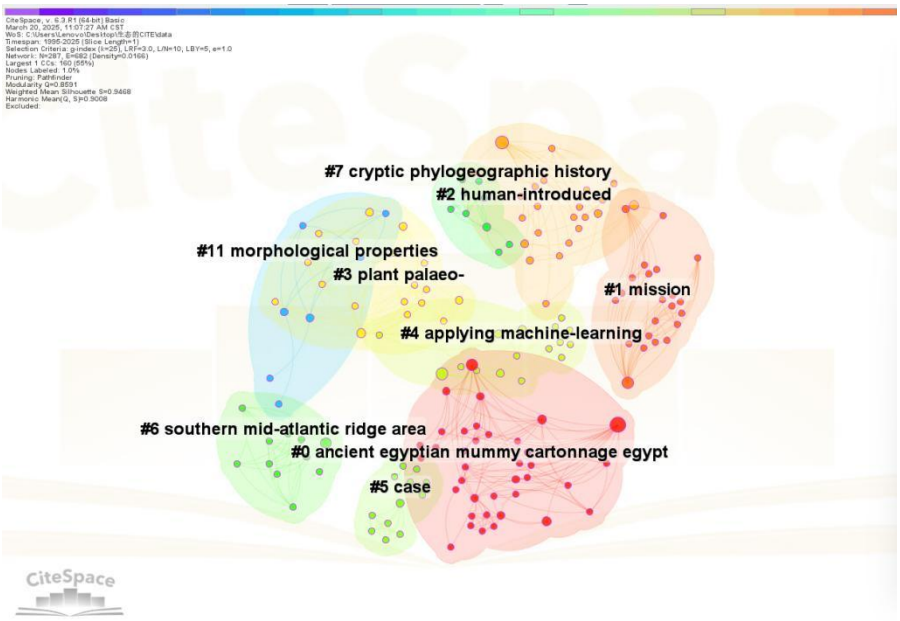

Figure2.Keyword clustering cluster diagram

3.2 Keyword Time Zone Analysis

The keyword time zone map clearly illustrates the evolution of research hotspots in eco-museum studies over time, as shown in Figure 3. Each keyword's position in the map represents the year it first appeared in the research timeline, while the connecting lines reveal relationships between keywords.

From the map, it is evident that early research primarily focused on topics such as virtual museums and cultural landscapes. Over time, the research emphasis gradually shifted towards community participation, climate change, and ecosystem management. Meanwhile, heritage conservation and sustainable development have remained core themes in eco-museum research.

The evolutionary trend in eco-museum studies has progressed from cultural heritage preservation to environmental sustainability, followed by an increasing focus on community interaction and cultural tourism integration. This indicates that eco-museum research is no longer limited to heritage conservation but is increasingly incorporating topics such as ecological sustainability and environmental adaptability.

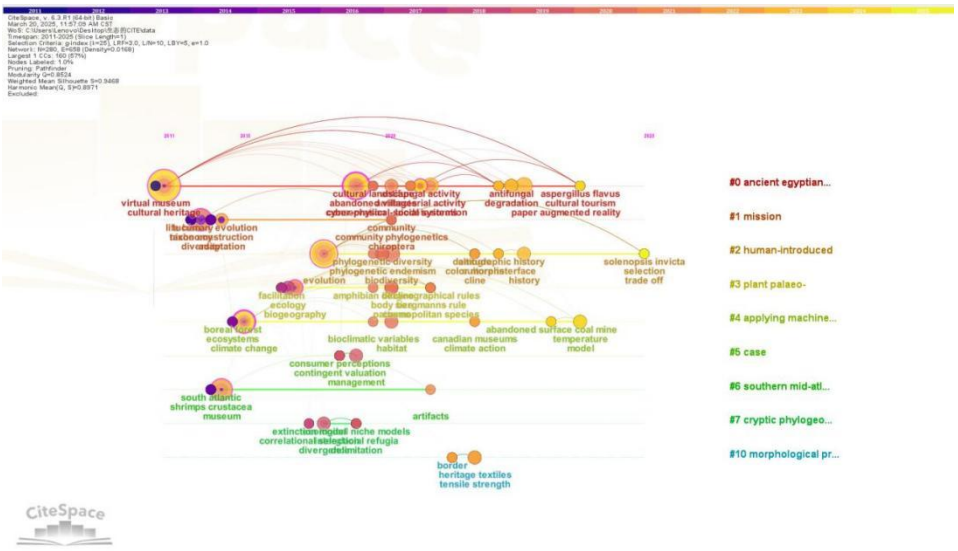

Figure3.Keyword Time Zone Map

3.3 Burst Keyword Analysis

In bibliometric analysis, identifying highly emergent keywords is crucial. By analyzing burst terms, researchers can explore the temporal distribution of keywords, detect rapidly growing and frequently changing terms, and thus identify the emerging research frontiers and key topics in eco-museum studies at different time periods. The burst keyword analysis was conducted using CiteSpace, and the detailed results are shown in Figure 4.

The strongest burst keyword identified is "museum." The core concept of museums, their expanding functions, and their relationship with ecological environments and cultural heritage conservation occupy a central position in this research field. Additionally, changes in burst keywords reflect the transition of eco-museum research from theoretical discussions to practical applications. Museums, as key carriers of cultural heritage conservation, not only serve as platforms for displaying tangible heritage but also increasingly emphasize the active transmission of intangible cultural heritage.

From a temporal perspective, eco-museum research hotspots exhibit a phased evolution. Early studies primarily focused on the conceptual framework and theoretical foundations of eco-museums, whereas recent research has increasingly emphasized practical models in different global regions, community interaction mechanisms, and the role of eco-museums in addressing global environmental changes. This trend indicates that eco-museums are not merely an extension of traditional museums but also integral to social development and cultural sustainability.

The most recent burst keyword is "sustainable development." This indicates a gradual shift in eco-museum research toward sustainability, reflecting growing academic interest in the long-term impact of eco-museums on environmental protection, community development, and cultural heritage preservation. As a museum model that integrates cultural heritage conservation with community engagement, eco-museums naturally align with sustainable development principles. Sustainability not only emphasizes natural ecological conservation but also stresses the active transmission of culture, aligning with the core goal of eco-museums to achieve harmonious coexistence of culture, society, and the environment through holistic conservation. In recent years, with the increasing global focus on sustainability, eco-museum research has expanded to include topics such as environmentally friendly management, sustainable tourism, and green museum construction.

The longest-lasting burst keyword is "cultural heritage." This confirms that cultural heritage has always been the core theme in eco-museum research, spanning the entire developmental process of the field. Cultural heritage is not only the primary conservation focus of eco-museums but also the foundation of their theoretical and practical framework. As an innovative museum model, eco-museums emphasize the holistic conservation of cultural heritage and natural environments, surpassing the closed exhibition approach of traditional museums by situating cultural heritage within its original context and ensuring its transmission and regeneration through active conservation and community participation. Future research is expected to place greater emphasis on the integration of cultural heritage with technology, including digital eco-museums and virtual reality exhibitions.

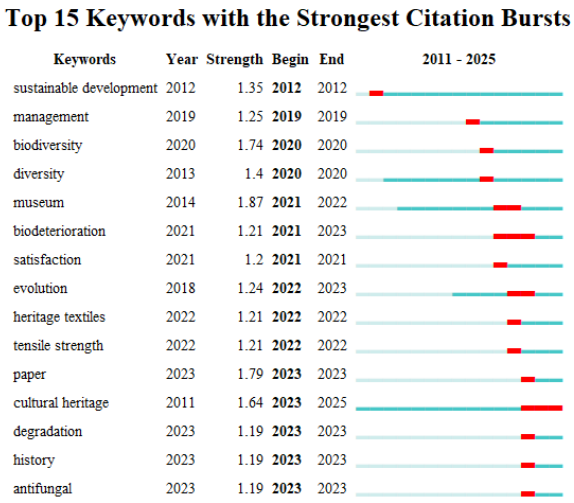

Figure4.Analysis of Hotspot Word Emergence

4.CONCLUSION

This study analyzed the research trends and developments in eco-museums using CiteSpace to visualize the knowledge structure and evolution of the field. Through keyword analysis, burst term detection, and clustering, several key findings have emerged.In conclusion, the evolution of eco-museum research indicates a transition from static heritage conservation to dynamic, community-driven, and sustainability-focused practices. Moving forward, integrating digital technologies, participatory governance, and interdisciplinary research approaches will be essential in ensuring that eco-museums continue to serve as effective models for preserving heritage while fostering sustainable development.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, author-ship, and/or publication of this article.

DATA SHARING AGREEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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