The Belt and Road Initiative

Subjects: Environmental Sciences

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The Belt and Road Initiative (BRI), proposed by Chinese President Xi Jinping in 2013, is an international initiative with vital implications for the economy, society, culture, and the environment. Consisting of the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road", the BRI was inherited and developed from the ancient Silk Road that played an essential role in connecting the West with the East on various socio-economic levels with its spirit of peace, friendship, inclusiveness, openness, and mutual benefit for many centuries.

the Belt and Road Initiative (BRI) environmental geography ecosystem services regional development

1. Introduction of the Belt and Road Initiative

The "Belt and Road" Initiative (BRI), i.e., the official Chinese term for the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road", was proposed to share China's development opportunities with BRI-related countries and achieve common prosperity. As China's most ambitious long-term regional infrastructure project, the BRI primarily aims to provide unparalleled for international economic cooperation, enhancing trade and connectivity between Asia, Africa and Europe with terrestrial and maritime routes . Up to now, the BRI has officially involved 147 countries and 32 international organizations [1]. The BRI-related countries and regions constitute nearly 70% of the world’s population and account for more than 50% of global output [2]. It is projected that the population of Belt and Road countries (including China) will reach approximately 5.4 billion by 2030 [3]. The BRI will serve as a positive move toward cooperation among the Belt and Road regions, stimulating the economic momentum of member countries and countries along the routes. In addition, the BRI intends to increase understanding and trust among BRI-involved countries and aims to achieve policy coordination, infrastructure connectivity, unimpeded trade, financial integration, and person-to-person bonds in Asia, Europe, and Africa [4].

2. Current Status of the Belt and Road Initiative

The BRI has yielded fruitful results since it was proposed. From 2013 to September 2021, the cumulative value of trade in goods between China and BRI-involved countries amounted to USD 10.4 trillion [5]. In 2021, non-financial direct investment by Chinese enterprises in 56 countries along the Belt and Road routes amounted to USD 20.3 billion [6]. Furthermore, China–Europe freight trains have formed a grand channel for international trade spanning Eurasia. By the end of October 2021, a total of 73 routes for China–Europe freight trains had been launched, linking China with 175 cities in 23 European countries, and more than 46,000 trips had been made by these trains

[5]. However, given the unprecedented dimensions of this initiative, many scholars have voiced concerns about its negative ecological and environmental impacts. Some have maintained that current official BRI investment remains heavily concentrated on fossil fuels, traditional forms of transportation infrastructure, and climate-unfriendly sectors [7]. Still, others argued that the changes in China's policy priorities toward a greener economy could create a framework enabling China to outsource its polluting industries elsewhere while at the same time shifting its domestic economy to a new phase defined by the adoption of green technologies [8].

In fact, most countries and regions along the BRI routes are in sensitive zones of climate and geological change, with complex natural and fragile ecological environments. Therefore, it is understandable that socioeconomic development may sometimes be accompanied by some inevitable impacts on the ecology and environment. However, some scholars used the environmental consequences brought by the BRI as political attack tools and published their opinions with obvious political intent in scientific journals. Researchers found that some ecological issues were, to a certain extent, subjective assumptions. Regional ecosystem health and environmental problems are scientific issues that need to be addressed and researched scientifically and not to be politicized subjectively. Therefore, researchers try to use Cite Space to analyze the relevant papers published from 2013 to 2021 and review the ecological and environmental problems raised by the scholars in details. Meanwhile, researchers propose some suggestions for research issues on ecosystem health and environmental geography in the Belt and Road regions in the future.

3. Quantitative Analysis of Environmental Studies Relating to the Belt and Road Initiative

3.1. Publications and Citations

To identify quantitative studies relating to the ecological issues of the Belt and Road regions, researchers performed a systematic search of scientific literature from the ISI Web of Knowledge (www.isiwebofknowledge.com (accessed on 18 April 2022)), which provides access to peer-reviewed studies. Researchers conducted a pre-test, searching these databases for literature published between January 2013 and December 2021, and using the following search term combinations: ("belt and road" OR "silk road" OR "one road, one belt") AND ("environment*" OR "ecosystem*" OR "ecolog*"). Finally, researchers obtained 623 qualified published references with related information on publication countries, years, authors, institutions, abstracts, keywords, journals, and their cited references.

After checking the search results, researchers found that "environment", presenting polysemy, in most cases meant abstract background such as business environment or government-governance environment, which deviated from the ecological environment theme. Therefore, researchers adjusted the search term to give a more specific meaning to "environment". Eventually, researchers obtained 470 requested records by retrieving the search term combinations (TS = "belt and road" OR "silk road" OR "one road, one belt") AND (TS = "environmental" OR "eco-*" OR "pollution" OR "emission" OR "ecolog*" OR "climat*") and eliminating irrelevant articles. Meanwhile,

researchers repeated the same operation on CNKI and obtained 108 English articles, only to find that they were completely covered by the ISI Web data.

Since the BRI was first put forward in 2013, the ecology and environment of the “Belt and Road” regions have not obtained enough attention and there are few related publications from 2013 to 2015 (**Figure 1**). In 2016, the Chinese government released the 13th Five-Year Plan for ecological environment protection, which set the goals for a more environmentally friendly lifestyle, a considerable reduction in the discharge of pollutant emissions, effective control of environmental risks, and a sounder ecological system. As the concept of ecological civilization is deeply rooted in people’s hearts, promoting green Belt and Road to lead the international trend of green, low-carbon, and circular development is an inevitable and effective way to boost sustained and sound economic growth. In May 2017, relevant departments of the Chinese government jointly issued the “Guidance on Promoting a Green Belt and Road” to further promote the green development of the Belt and Road regions. Therefore, the number of related references has grown exponentially since 2017 (**Figure 1**). In recent years, environmental discussions in the Belt and Road regions have been sprouting up. As the topic becomes more attractive, the number of citations also increases yearly (**Figure 1**), which confirms the value of the research.

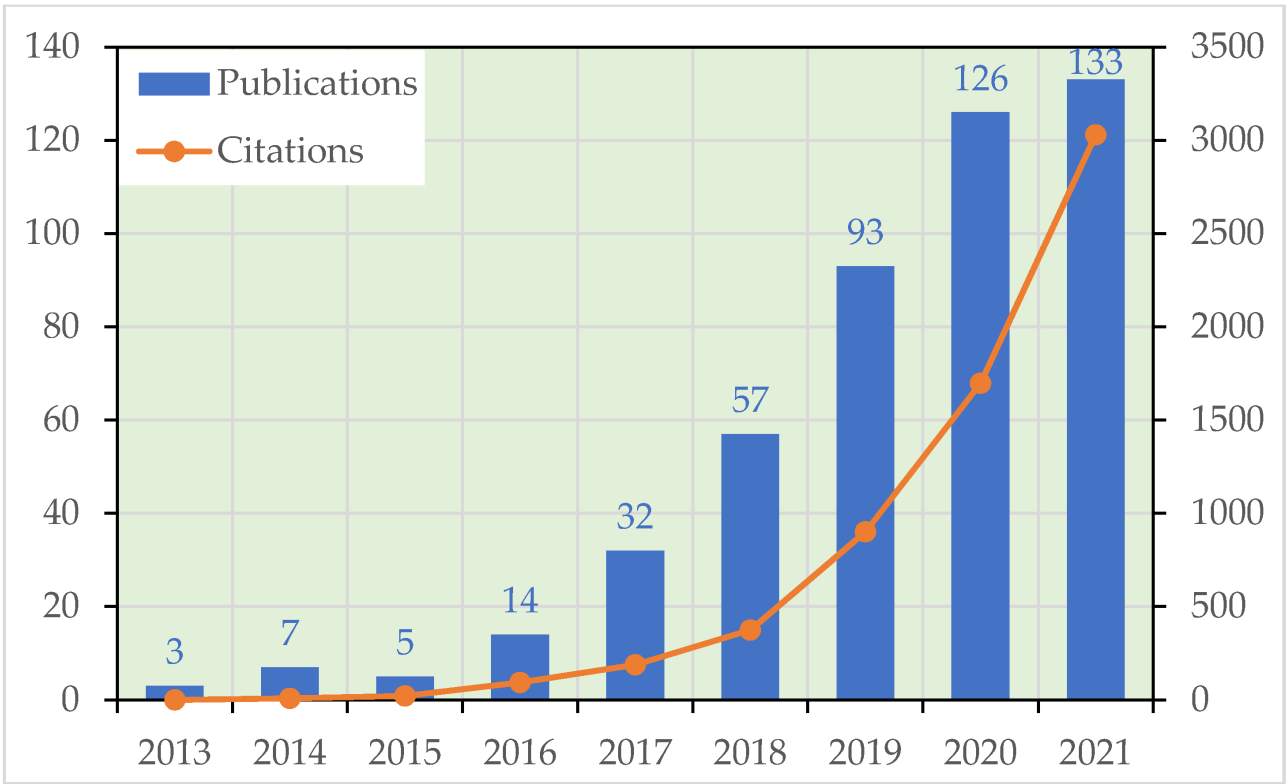

Figure 1. Dynamics of the annual number of published articles concerning ecological issues in the Belt and Road regions.

3.2. Interested Countries and Regions

CiteSpace is a scientometric software that can be used to generate knowledge domain visualization and detect emerging trends in scientific literature [9][10]. The retrieved articles were imported into CiteSpace 5.8.R3 for further

analysis following the process: Time Slicing set as “From 2013 to 2021”, Link set as Cosine, and Selection Criteria set as g-index = 25. After processing, researchers obtained the merged co-country network map with 48 notes and 166 links (**Figure 2**). Besides China, the main countries concerned about the ecological and environmental issues of the Belt and Road regions can be divided into 2 categories.

Figure 2. Co-country network of ecological issues in the Belt and Road regions.

The first category consists of countries along the route, particularly those near the first stop of the BRI, mainly in South and Southeast Asia (**Figure 3**). These nations act as the hubs for “the oceans and continent” trade networks of the BRI such as Malaysia, Singapore, and Pakistan, etc. The ecological problems there are more complex, involving both marine and terrestrial ecosystems, which leaves room for further exploration. The European countries at the terminus of the route, such as Germany and the Netherlands, are characterized by an eco-friendly consciousness and are always alert to potential environmental dangers.

Figure 3. Road map for the "One Belt One Road" and location of interested regions (Red oval is used to show the location of interested region).

The other is the countries that geographically deviated from the six economic corridors of the Belt and Road Initiative such as the United States, South Korea, Japan, and Australia. Although these countries are not in important areas alongside the Belt and Road regions, they have close economic ties with China, always keeping a watchful eye on China's dynamics and development. Consequently, the BRI policy has become a topic of interest for them.

3.3. The Evolution of Research Hotspots

Researchers used CiteSpace 5.8.R3 to analyze the network of co-occurring keywords by setting pathfinder pruning (**Figure 4**). The knowledge network shows 320 notes and 609 links, resulting in 22 clusters. The top 11 clusters contain more than 10 keywords, displaying diverse research theses, study objects, and research methods (**Figure 5**). The modularity Q value is 0.812 and the silhouette S value is 0.9176, which mean that the structure of the cluster data is clear and the results are reliable.

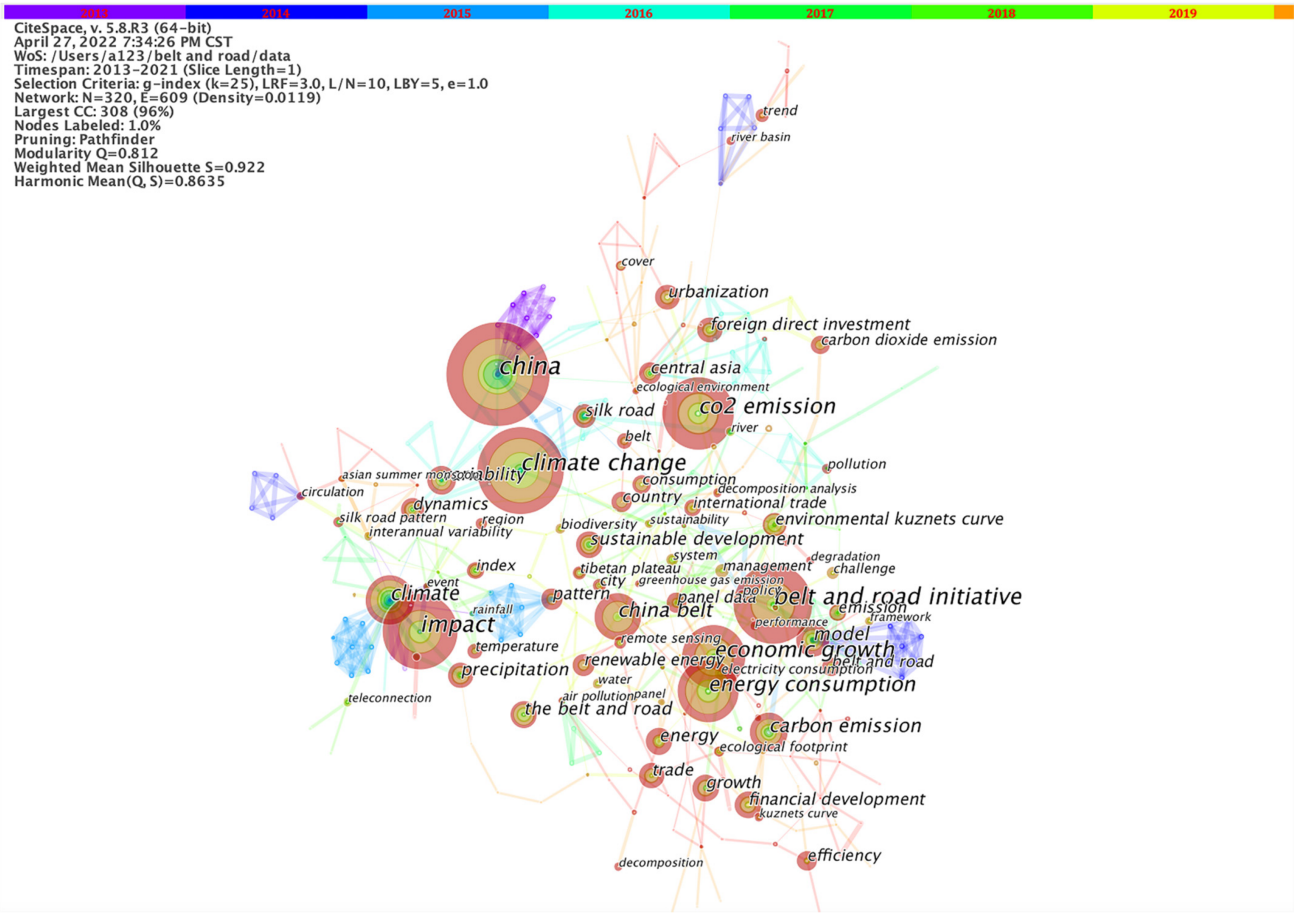

Figure 4. High-frequency keywords scatter view of ecological issues of the Belt and Road.

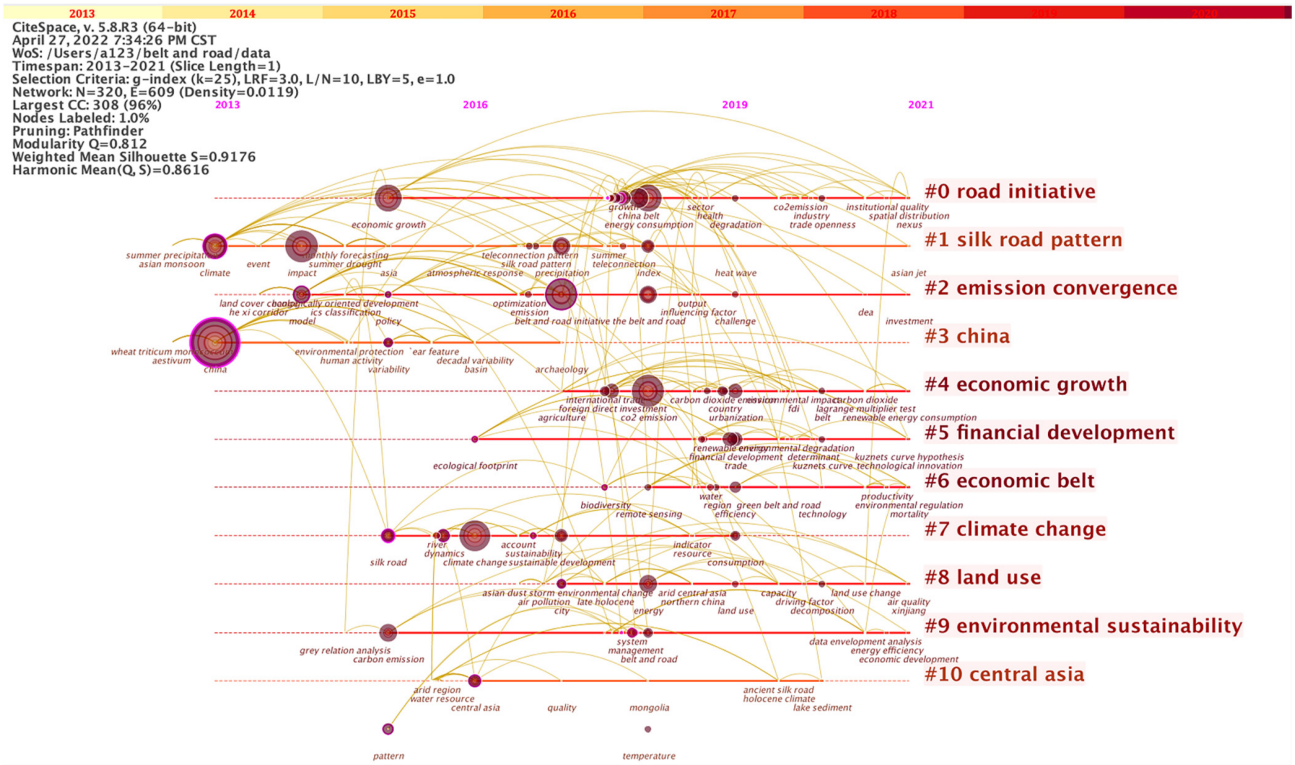

Figure 5. Keywords timeline view of ecological issues of the Belt and Road.

The clustering of keywords reflects the change in research hotspots and shows the evolution of ecological environment research along the Belt and Road [11] routes. Cluster #0 (road initiative) refers to the Belt and Road Initiative; its main content is to unscramble the target and empirically examine the influence of this policy on the world. Due to the continuous advancement of this initiative, policy research and empirical study will carry on. Cluster #1 (silk road pattern) is a meteorological teleconnection pattern covering most domains along the ancient Silk Road and exerting a significant impact on climatic anomalies over a broad area of the Eurasian continent. Cluster #2 (emission coverage) focuses on greenhouse and other gas emissions in construction and freight transportation. In the context of low-carbon development, carbon emission transfer and carbon emission efficiency have become the hot spot of research. Cluster #3 (China) implies China, as the initiator of this policy, was the core object of study before 2017. Cluster #4 conveys the influence of economic activities such as commodity trade and foreign investment on the ecological environment. Cluster #5 describes a more specific relationship between financial flow and the environment. Cluster #6 (economic belt) is an abbreviation of the belt economic zone, emphasizing the unique geographical advantages of the regions along the Silk Road such as demographic structure, productivity level, resource endowment, etc. Cluster #7 indicates how climate changes affect regional development. Unlike Cluster #1 which uses remote sensing technology to predict and monitor climate change, Cluster #7 focuses on the effects of climate change and has stagnated in 2019. Cluster #8 refers to land use. Although this topic appeared relatively recently, its extensive scope highlights its research significance. The changes in the landscape and soil environment prompted by land use are due to the primary interference by human activity in the natural environment. Cluster #9 stresses that environmental sustainability has become a curtailed evaluation index for the projection of the BRI. Cluster #10 reveals that Central Asia was once the center of attention for its glorious history of the ancient Silk Road Period and its fragile ecological environment. In terms of the vitality of keywords, the ecological research of the Belt and Road Initiative presents the following characteristics: using high-tech solutions, intertwining with the economy, excavating policy connotations in-depth, and analyzing human activities.

3.4. The Development Venation of Research

The visualized analysis of the references can reveal the intellectual base and research front of the research. The intellectual base is the co-citation venation, and the research front is the derivative of the knowledge base and represents the emerging research direction or subject [12]. Researchers still set the Selection Criteria as g-index = 25 and pruned the network using the pathfinder. The results are shown in **Figure 6**.

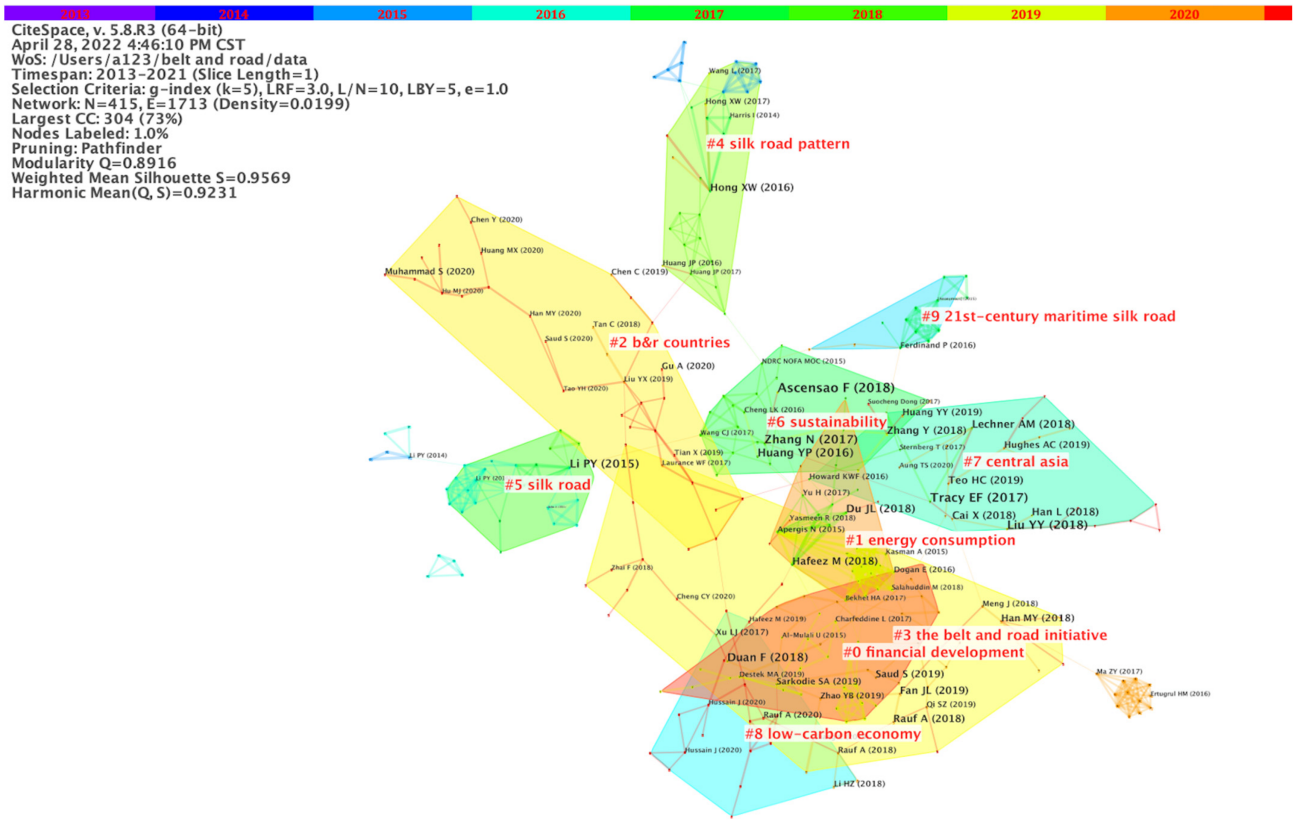

Figure 6. Literature co-citation cluster network of ecological issues in the Belt and Road regions.

After calculation, 62 clusters were finally obtained. Researchers selected the 10 largest clusters with tight relationships. **Figure 6** shows that the BRI (Cluster #3) serves as an intermediary, linking different topics. Among them, financial development (Cluster #0) and low-carbon economy (Cluster #8) are closely tied up with the Belt and Road Initiative, reflecting the core pursuit of the Belt and Road construction. Energy trade is also an important issue in the Silk Road region. During the process of energy cooperation, the importance of Central Asian countries cannot be ignored and environmental sustainability must be taken into account.

Figure 7 shows the evolution of the research topics. The Belt and Road ecological environment study began with the three clusters—“silk road pattern”, “silk road”, and “21st Century Maritime Silk Road”. The original subjects of the study are monsoon activities, soil and water management, and the marine environment, respectively [13][14][15][16]. Natural ecological changes and the impact of human activities on the environment are the starting point of the initial research. Between 2013 and 2016, the number of clusters #0, #1, and #6 increased dramatically. During this period, research on land creation shows the strongest citation bursts, which means that the empirical study on the interaction between economic development and the ecological environment has become the focus of discussion [17]. At the same time, people began to reflect on the negative impacts of economic benefits on the ecological environment and realized the importance of environmental sustainability. The citation burst revealed the research hot spot for a period of time, suggesting that the research changed direction [10]. The latest three citation bursts [18][19][20] documented energy investment, regional temperature changes, and the environmental Kuznets curve, suggesting a future trend of ecological environment research along the Belt and Road routes: (1) climate change caused by atmospheric activity and monitored by remote sensing; (2) establishing an environmental assessment

mechanism; (3) evaluating economic activity from the perspective of the environmental costs, especially energy consumption; (4) exploring the relationship between economic development and the ecological environment.

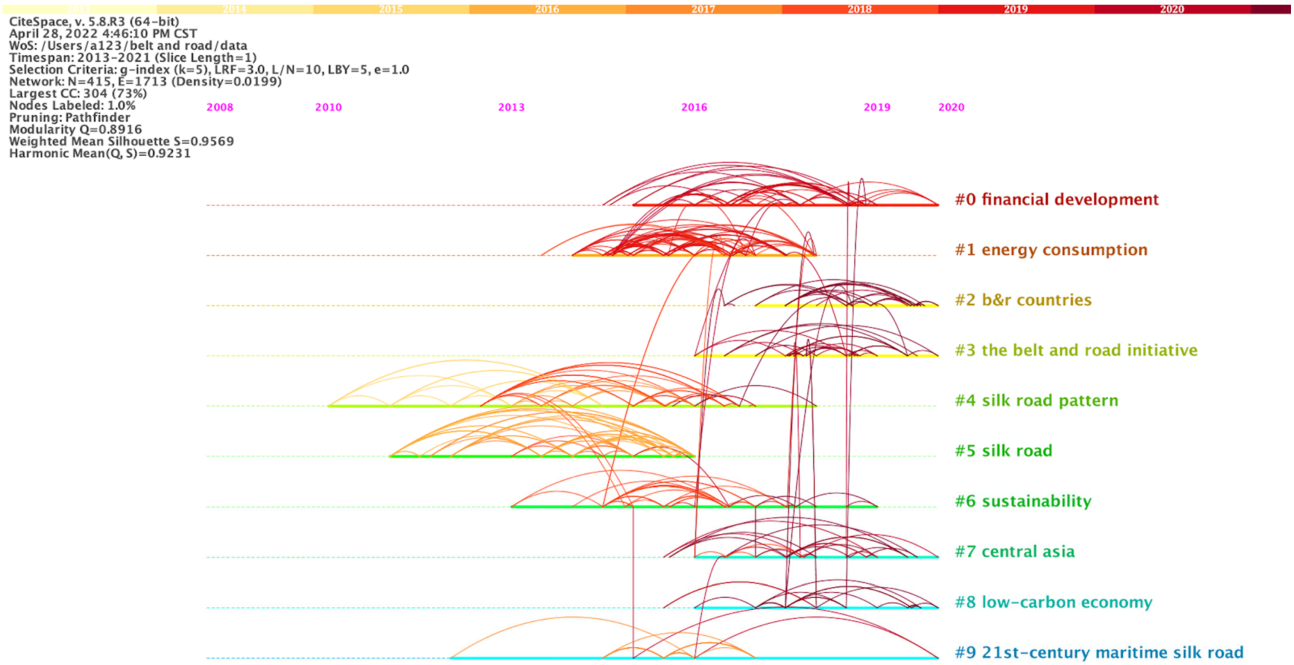

Figure 7. Literature co-citation timeline view of ecological issues in the Belt and Road regions.

4. New Prospects for Ecological and Environmental Studies of the Belt and Road Initiative

In view of the potential environmental challenges proposed by scholars and the deficiencies in existing research, these environmental challenges should be addressed by scientific means. The focuses for future study on environmental challenges of the BRI are recommended as follows.

4.1. Spatial Analysis and Monitoring Technology for the Environment

The lack of comprehensive and up-to-date data is a key obstacle to in-depth research on the ecological environment of the BRI. Spatial analysis and monitoring technology can provide large-scale monitoring tools to obtain data on the status and changing trends of ecological and environmental quality. These scientific data can be used to judge the level of environmental pollution and quality, objectively evaluate the current main ecological and environmental problems. Therefore, to better and more objectively assess the ecologies and environments of the Belt and Road regions, more research is needed using spatial analysis and monitoring technologies

4.2. Clarification of Characteristics and Mechanisms of Ecosystems and Environments

4.2.1. Ecosystem Health

Ecosystem health, a kind of functional manifestation of ecosystem operation, can ensure the ecosystem develops well [21]. Ecosystem health is a comprehensive characteristic of the ecosystem, which can reflect the regional ecological environment from multiple perspectives. It can be described as a comprehensive, multiscale guiding framework in the evaluation of ecosystem vigor, organization, and resilience [22][23]. This evaluation mechanism of the ecosystem, comprising vigor (activity, metabolism, or primary productivity), organization (the diversity and number of interactions between system components), and resilience (the ability to maintain its structure and pattern of behavior in the presence of stress) [22][24], determines the assessment framework of ecosystem health and affects the identification of the regional environment. A systematic study of regional ecosystem health, therefore, can not only clarify the characteristics and spatial-temporal variations in regional ecological environments in the Belt and Road regions from multiple perspectives, but also contribute to the understanding of the driving mechanisms of regional ecological environmental change, providing a scientific basis for environmental protection under the BRI framework.

4.2.2. Environmental Impacts of the BRI

The potential impacts of the BRI proposed by scholars on the atmospheric, water, soil, geological, and biotic environment can be summarized and discussed. In addition, the driving factors of these effects (such as the factors affecting the carbon emissions by the transportation industry in countries in the BRI) and the direction and extent of these effects are both worthy of further discussion.

4.3. Focus on the Interactions between the Economy and the Environment

4.3.1. Regional Development and Ecosystem Health

As long as an ecosystem is healthy and well-protected, ecological and green industries can be developed to realize the economic value, thereby boosting regional development. Whether the ecological environments of the Belt and Road regions could support regional development and how to support it remain a largely unexplored area. Investigating the relationship between regional development and ecosystem health among these regions is the foundation for guaranteeing ecosystem health in order to promote regional development as a whole.

4.3.2. Economic Development and Ecological Protection

It is essential for future studies to attach importance to the relationship between development and protection. The relationship between economic development and the ecological environment should not be regarded as a zero-sum game. Does economic growth inevitably lead to ecological destruction? Is there a balanced model to achieve a "win-win" scenario for economic growth and environmental protection? Can this model be applied to future developments in the Belt and Road regions? These issues must be probed and clarified for further research.

4.4. Specific and Targeted Strategies and Solutions to Different Environmental Problems

Along with advances in BRI construction, infrastructure construction, export supply chains, and energy-intensive industries would surge, which could result in an increase in some unavoidable environmental problems such as greenhouse gas emissions, water pollution, and so on. Therefore, it is advisable to propose constructive strategies and solutions to environmental problems from different perspectives. Due to the different levels of development, financial status, sensitivity, and responsiveness to environmental changes in the Belt and Road regions, addressing environmental problems involved in the BRI is complex and multi-scaled. At the same time, the BRI infrastructure types could be divided into communication, transport, energy, and economic infrastructure and activities, all of which have different impacts on the environment. Therefore, it is essential to propose specific strategies and solutions to the environmental problems caused by various types of infrastructure in different regions.

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