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Research progress on eco-industry and rural revitalization and its implications for rocky desertification management areas

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Abstract: *The ecological industry of rocky desertification control is an important driving factor for rural revitalization and a key link in promoting the development of regional ecological, economic and social benefits, which is of great significance in consolidating the effectiveness of rocky desertification control and promoting rural revitalization. At present, the management of rocky desertification has achieved stage-by-stage results, and with the deepening of ecological civilization construction, it is necessary to establish and practice the concept of "two mountains" and comprehensively promote rural revitalization. Based on the WOS and CNKI databases, using the literature review method of search, evaluation and comprehensive report, a total of 169 relevant literatures were obtained, and the results show that (1) the number of articles issued is generally on the rise, and is divided into the budding development stage, the slow stage, and the rapid stage; (2) the research mainly includes the measurement of the level of rural revitalization, the measurement of the level of eco-industry, the driving factors of eco-industry on rural revitalization, the rural revitalization mode and optimization of eco-industry; (3) the research areas are mainly in relatively backward regions and rural revitalization experimental regions, and there is a high degree of overlap between the research hotspot areas and their geographic locations; (4) the main progress and landmark results are summarized according to the classification of the research content, and the scientific issues related to the eco-industry driving paths, level measurement, layout optimization, rural revitalization, and the effective interlocking driving mechanism between them are explored. The research is summarized according to the content of the research. Based on the above research, it is proposed to gain insights based on the chain development of eco-industry and rural revitalization based on karst rocky desertification governance.*

Keywords: *Ecological industry, Rural revitalization, Rocky desertification management, Research progress*

1. Introduction

Eco-industry (ECO) is an important part of safeguarding economic, environmental and social development and human well-being [1,2], which is an industrial system constructed based on the principles of ecology, the laws of ecological economics, and systems engineering methods [3]. Taking the structure, function and succession laws of natural ecosystems as reference, the ecological concept is deeply embedded in the planning, design, production, operation and management of industries. The book Silent Spring, first published in 1962, made people gradually begin to pay attention to ecological damage, resource depletion, environmental pollution and other issues, and the industrial ecological thought with ecology, recycling, renewable and high efficiency as the core concept was thus born [4]. Under the guidance of industrial ecological thought, stepping into the contemporary society with more serious environmental pollution problems and greater challenges to ecological civilization, the ecological industry that is more in line with the development of the contemporary society is gradually formed, different from the traditional industry that pursues the economy without pursuing the ecological model [5] (Table 1). In order to maintain the stability of the earth's ecosystem and the long-term interests of human beings, ecologists and economists have put forward the concept of eco-industry [6], aiming to reduce the consumption of natural resources and damage to the ecological environment through the adoption of sustainable production methods and resource utilization modes, to promote sustainable economic growth, to promote the fair and harmonious development of the society, to

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maintain the balance and stability of the ecosystem, and to lead the formation of the green, low-carbon and circular production and life style and values, in order to realize the harmonious coexistence of man and nature [7-9].

Table 1. Comparison of eco-industries and traditional industries

Category	Traditional primary, secondary and tertiary industries	Eco-industries
Objectives	Capturing the benefits of profitability	Harmonious development of man and nature
Paradigm	Fixed, single	Chain, mesh, adaptive
Functionality	Produces	Production, social services, ecological services, region building
Social impact	Reduced employment opportunities, mono-development	Increasing employment opportunities and promoting regional development
Environmental protection	End control, sabotage, high investment, low return	Integrated management, conservation, low investment, positive returns
Efficiency	Individual benefits	Integrated, holistic benefits
Sustainability	Resource dependence, low sustainability	Ecologically controlled and highly sustainable
Growing trend	Difficulty of turnover and dependence on external factors	Synergising progress and adapting to needs

Eco-industry is an important way for karst regions to realize high-quality leapfrog development while taking into account the dual goals of ecological environmental protection and economic growth. Conducting research on the driving factors of eco-industry on rural revitalization in karst areas is a powerful exploration on the road of rural revitalization development. Rocky desertification prevention and control is a complex and arduous task, and actively exploring the driving factors of ecological industry on rural revitalization provides theoretical references for the development of rural revitalization.

2. Materials and methods

The systematic literature review method was used in this study, which involves a series of processes such as developing a protocol, implementing a search strategy, evaluating the selected studies, synthesizing the findings, and writing a report (Table 2). The method has the advantages of a standardized and convenient logical system, transparency, independence, robustness, comprehensiveness, and reproducibility, and can be used to identify, assess, and synthesize the process of researchers' completed and documented work, and is suitable for conducting interdisciplinary literature reviews.

Table2. Literature search strings

Database	Retrieve String	Number	Retrieve Date
CNKI and WOS	First search string: “Rural revitalization”; Second search string: “Ecological industry”	369	2024.1.1
	First search string: “Ecological industry”; Second search string: “Industrial layout”	173	2024.1.1
Total number	Eco-industry driven rural revitalisation and industrial layout optimisation	542	2024.1.1

Note: The data here includes comments and original articles in all languages.

2.1. Literature retrieval

Based on the diversity and complexity of global languages and the significant regional nature of our research content, we selected Web of Science (WOS) and China Knowledge Network (CNKI) databases. English is a globally used and widely understood language, and WOS contains high-quality academic literature in various subject areas around the world, with fast data updates and a wide audience, so we chose the WOS database for English literature search. In addition, eco-industry and rural revitalization are concepts of Chinese characteristics, and rocky desertification management has a leading position in the karst of southern China, so the Chinese literature also has an important reference value.CNKI is the largest, the most numerous, the most comprehensive and the most important

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literature database in China, so we chose the CNKI database for the Chinese literature retrieval. In order to ensure the timeliness of the literature, the deadline for searching was January 1, 2024, which was the first day of the search.

By applying the pre-determined inclusion and exclusion criteria (Table2), we further assessed the content of the papers that met the inclusion criteria.

2.2. Identification

The inclusion criteria were based on specific keywords in the title, keywords or abstract, using literature from CNKI and WOS databases, and incorporating keywords related to “eco-industry” and “rural revitalization” and “industrial layout” in the content. Keywords related to “eco-industry” and “rural revitalization” and “industrial layout” were included in the content. The exclusion criteria included duplication, inaccessibility, lack of direct relevance to the research topic, and content unrelated to the research topic of this paper. After applying these criteria, 169 documents met all the inclusion requirements. Using a bibliometric approach , the 542 documents obtained from the search engine were reviewed for research content by strictly following the procedure developed in Figure 1. In addition, inclusion and exclusion criteria were applied additionally to the initial search results, and papers that met the inclusion criteria were selected for further review and content assessment.

The screened 169 articles that were highly relevant to the study topic were included in the procedure to form the final sample for this study, including 96 Chinese journal articles, 23 foreign journal articles, 11 master's and doctoral dissertations, 6 conference-type articles, 8 newspapers, and 25 yearbooks.

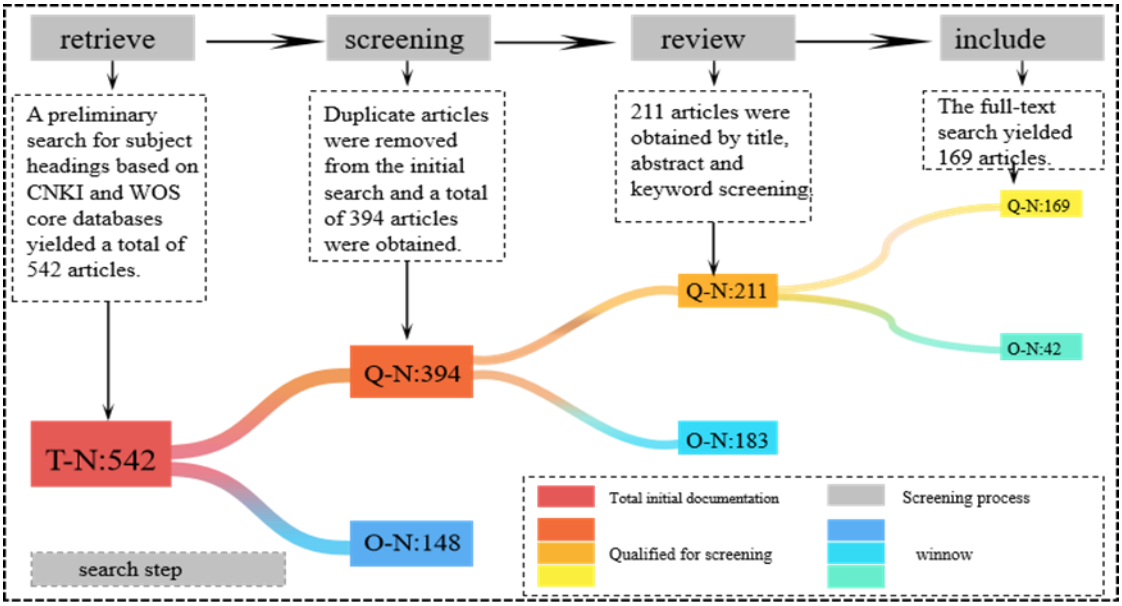

Figure 1: The systematic mapping process of research literature acquisition integrates the four steps of Retrieve,Screening,Eligibility and Inclusion.(T-N:The total number of initial;Q-N:Number of screening qualified;O-N:Number of screening out)

3. Results and Analyses

3.1. Annual distribution

The retrieved research on eco-industry and rural revitalization began at the beginning of the 21st century, and the concept of eco-industry began to be put forward earlier, and it can be seen through the analysis of Figure 2 that the research on rural revitalization and eco-industry can be roughly divided into two phases during the period from 2006 to 2020 (Figure 2). In the first stage 2006-2017, the number of relevant research literature is relatively small, and the annual growth in the number of literature is similarly small, showing that the relevant research is in the beginning stage, the reason is that both domestic and foreign countries, the concept of rural revitalization has only just been put forward, and there are fewer and less in-depth and immature studies on this aspect; the second stage is

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from 2018 to the present year, when the concept of rural revitalization is put forward, and as a result of the in-depth deployment of national policies, rural revitalization is in full swing, and the research is gradually deepening and maturing, and the relevant research is growing by leaps and bounds.

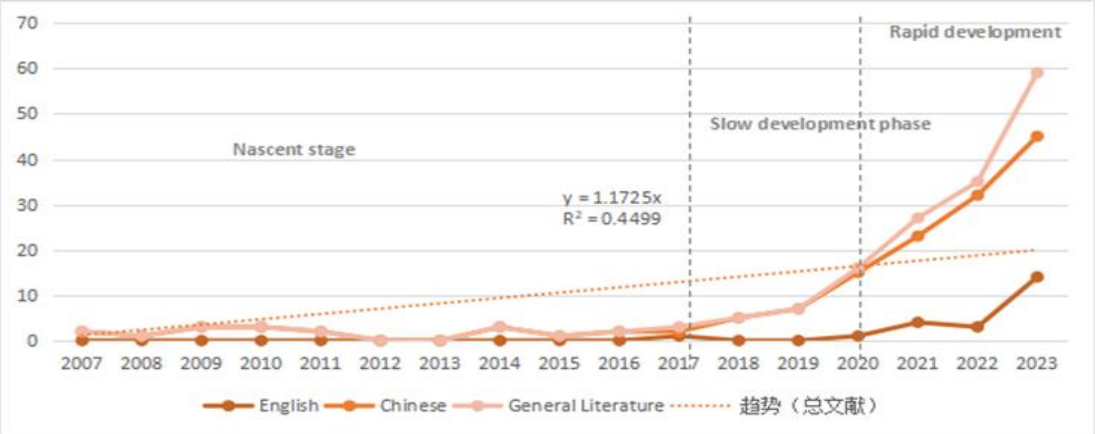

Figure 2: Annual distribution of literature

3.2. Content Distribution

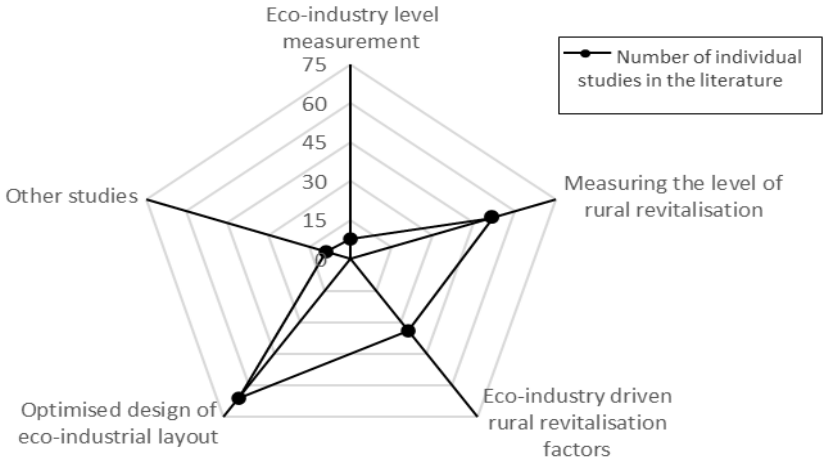

Figure 3: Classification of research literature related to rural revitalization and eco-industry

After intensive reading and analysis of 169 domestic and foreign literatures after search and screening, they can be classified into five categories according to the research content: rural revitalization, eco-industry, industrial integration, technology path and others (Figure 3). Among them, 52 articles on rural revitalization level measurement, accounting for 30.77% of the total 169, 8 articles on eco-industry level measurement, accounting for 4.73%, 34 articles on eco-industry-driven rural revitalization factor analysis, accounting for 20.12%, 66 articles on eco-industry layout optimization and design, accounting for 39.05%, and 9 articles on other related studies, accounting for 5.33%. In the searched literature, the most relevant literature on the measurement of rural revitalization level is followed by the literature on the measurement of eco-industry level, and the research on the factors of eco-industry-driven rural revitalization is becoming more and more mature, but the research on the optimal design of eco-industry is relatively less. Other studies currently focus more on ecological issues related to the countryside and segmented rural industries.

3.3. Distribution of Research Regions and Research Organisations

Due to the small number of relevant studies abroad, this study only counted the countries and regions where the number of literature was greater than or equal to 2 articles. Among the foreign literatures searched, Asia published the largest number of literatures, accounting for 85.78% of the total number of publications, followed by North America (10.06%) and South America (1.8%). At the national level, China published the largest number of publications, with 145, accounting for 85.80 per

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cent of the total. It was followed by the United States, which published seven documents, accounting for 29.17 per cent of the foreign research literature. Canadian ranked third with three publications, accounting for 12.5 per cent of the foreign literature. This was followed by Australia and Argentina with 4 publications accounting for 16.67 per cent of the foreign literature. In addition, there are also a few studies in countries such as Italy, Spain and Norway with less than 2 pieces of literature (Figure 4).

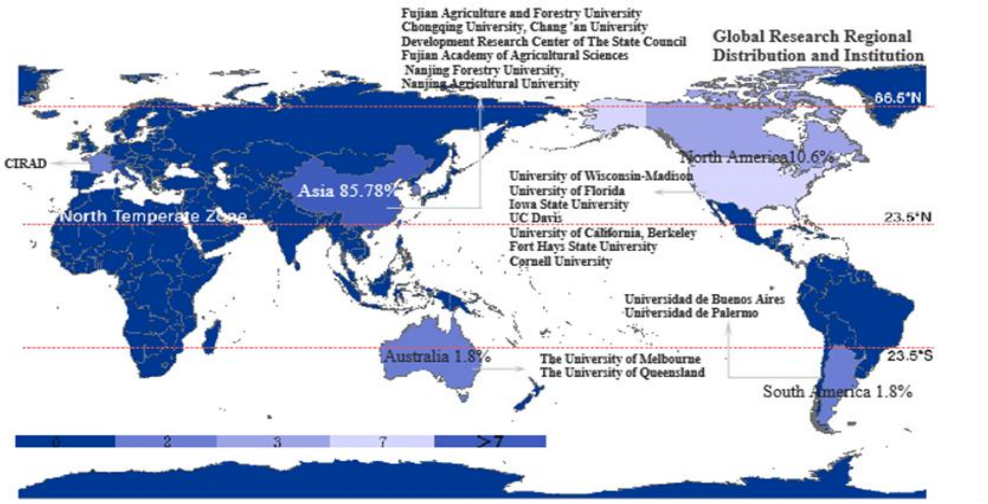

Figure 4: Global literature research and regional distribution of major institutions

Among the 169 Chinese and foreign literature retrieved (Figures 5), the literature is more abundant. The main units of literature generation are domestic agricultural agriculture and forestry colleges and research institutes. The largest number of literature for the Fujian Agriculture and Forestry University, published 7, followed by Chongqing University and Chang'an University for 3, literature in 3 and more than 9 units, respectively, Fujian Agriculture and Forestry University, Chongqing University, Chang'an University, the Development Research Centre of the State Council, Fujian Academy of Agricultural Sciences, Nanjing Forestry University, Nanjing Agricultural University, Guizhou Daily Newspaper. Among the issuing units with more literature, there are more colleges and universities of agriculture, forestry and agriculture, followed by units in developed regions and regions in the main position of rural revitalisation strategy.

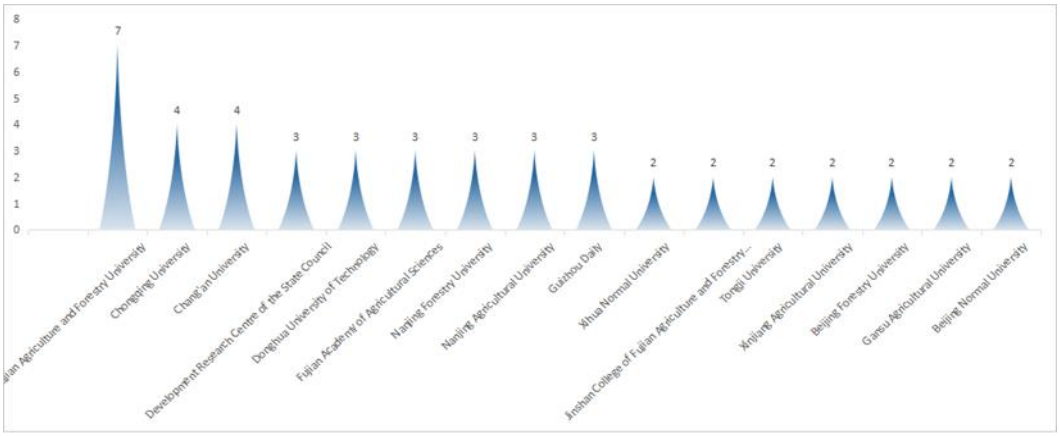

Figure 5: Literatures distribution unit

3.4. Research progress and landmark results

3.4.1. Research on the measurement of the level of eco-industry

①The study of the development level of eco-industry is the focus of the current eco-economy (Figures 6) , aiming at sys tematically assessing and quantifying the development status of eco-industry, so as to give full play to the multiple advantages of natural resources, and vigorously develop eco-cultivation, eco-tourism, eco-industrial agriculture, and other industries, so as to create an eco-industrial chain. By analyzing the utilization benefits of energy, land and water resources and testing

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the environmental quality of air, water and soil, etc., it is possible to assess whether the role of eco-industry on the ecological environment is positive or negative, and optimize it according to the actual situation. Under the background of vigorously promoting rural revitalization, the current ecological industry in rural areas is booming, and the development of ecological industry can bring employment opportunities and solve the problem of farmers' employment, and at the same time, the economic benefits it generates are an important driving force to promote rural revitalization [29-31], and the indicators of output value and employment are directly related to the economic contribution of ecological industry to the local economy, and by using these data, it is possible to quantify the positive impact of eco-industry on the job market and national economy.

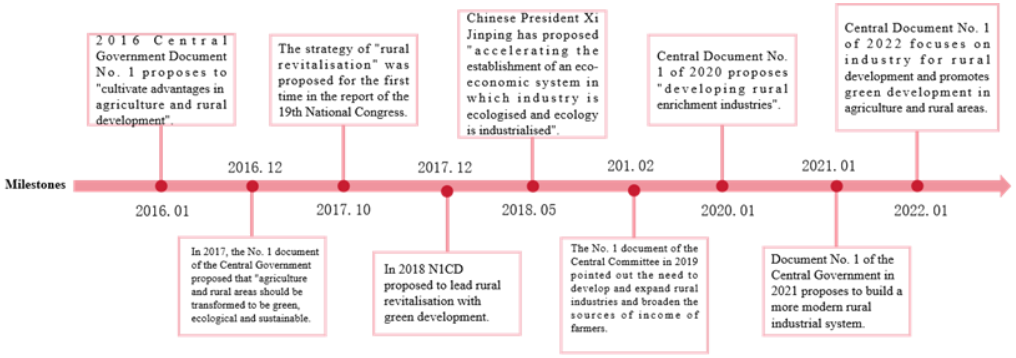

Figure 6. History of theory formulation of eco-industry and rural revitalization

3.4.2. Study on the Measurement of the Level of Rural Revitalisation

①In the practice of rural revitalization, regional development differences are important influencing factors for the promotion of rural revitalization (Figures 7). At present, the inadequacy and imbalance of the construction of livable and beautiful countryside in China are still prominent, and the inter-regional differences are the main reason [15]. There are differences in the economic foundation and resource endowment of different regions, leading to different starting points and development paths for rural revitalization. Some resource-rich regions may be easier to achieve the development of rural revitalization, while some resource-poor regions face greater challenges Meanwhile, relatively developed regions have given more support to the implementation of this policy, including financial funds, project support, etc., while relatively backward regions have lagged behind due to insufficient infrastructure construction, which has hindered the upgrading of rural industries and market development , and are subject to a variety of economic, social and other factors, which have led to the lack of support, and it is difficult to promote the implementation of the policy by relying only on the local self-powers. The industrial structure and characteristic advantages of different regions are also important reasons for the development differences, some regions may mainly rely on traditional agriculture for development, while others may achieve economic diversification through the development of modern agriculture, rural tourism and other emerging industries . Environmental and ecological issues are important considerations for rural revitalization, and areas with good habitats are revitalized through ecological agriculture and sustainable development, while rocky desertification areas with fragmented habitats and fewer land resources are hindered from sustainable development due to environmental issues.

Figure 7: Theory of development strategy for rural revitalization

3.4.3. Analytical Study on Factors Driving Rural Revitalization by Eco-Industry

①In order to take the road of ecological industry development, the countryside should first

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understand the amount of ecological resources it possesses (Figures 8) , so it is necessary to comprehensively analyze the ecosystem services that the countryside possesses, and quantify and comprehensively analyze the ecological functions, such as water conservation, soil retention and biodiversity, so as to derive its sustainable value for society, economy and environment, and provide a guarantee for the revitalization of the countryside. The countryside is mainly based on agriculture, and in order to take a path of sustainable development, it is necessary to protect before development and development, protect soil and water through no pesticides, no chemical fertilizers and appropriate farming methods, and at the same time, establish a perfect ecological industry chain, from development, production, processing to sales, so as to mention the strategy to attract tourists to consume through the natural scenery and ecological landscapes, and to promote the diversification of the economy (Figures 9).

The systematic research on ecological resource assessment and integrated utilization not only provides a theoretical framework for rural revitalization but also offers scientific guidance for practical operations. In rocky desertification areas with scarce resources of their own, efforts should be concentrated on accomplishing major undertakings. Adopting the sustainable development path of ecological industries, promoting rural revitalization, and realizing the coordinated development of the ecological environment and the economy can lay a solid foundation for sustainable rural revitalization in the future.

Figure 8: The rich natural resources of the Red Maple Lake study area in Qingzhen

Figure 9: Natural Resources in Bijie Sala Creek Study Area and Guanling-Zhenfeng Huajiang Study Area

②Natural ecological resources not only have the function of ecological nourishment, but also can provide ecological products, and the ecological culture derived from this is popular in the market (Figures 10) [26]. Stone desertification areas are relatively rich in natural ecological resources, especially the unique karst landscape, in the ecological resources have become scarce commodities, can make full use of this natural advantage to develop ecological industry.By means of managing, protecting and utilizing natural ecological resources, we can expand the multiple functions of natural ecological resources and develop the rural ecological vacation tourism industry. In addition to the industrialization of natural ecological resources in mountainous areas, many “wetland parks” have been constructed in plain water towns and water resource-rich areas on the basis of the strict implementation of the red line of water resource protection, and scientific and comprehensive development and utilization have been carried out. Xiong Kangning et al. researched the ecological restoration of vegetation communities and developed the synergistic and coupled development of environmental bioenergy industry, biomedical industry, mountain tourism industry and other suitable industries in karst areas . In summary, combing the development and evolution of ecological industry in karst areas, clarifying its main economic development factors, ecological resources are its main development basis, after years of rocky desertification control, the development of ecological industry in rocky desertification areas has achieved remarkable results. On this basis, adhere to the development and

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expansion of rural industries rural revitalization strategy implementation of the primary position, relying on the revitalization of rural construction, to create rural industries, to promote the high-speed development of rural revitalization .

Figure 10: Prickly pear industry derivatives prickly pear juice, pepper industry derivatives pepper oil,Dragon Fruit Industry Derivatives Dragon Fruit Wine (Source: Internet)

3.4.4. Research on Optimized Design of Eco-Industrial Layout

Figure 11: a,b industrial layout of trellis planting in the Red Maple Lake study area, c industrial layout of planting in the Salad Creek study area, and d industrial layout of scrip farming in the Guanling-Zhenfeng Huajiang study area

①The optimal design of eco-industrial layout (Figures 11) is an important way to achieve synergistic development of economy and ecology, and its goal is to protect and restore the ecological environment while meeting the needs of industrial development . In order to achieve the optimization of eco-industrial layout, a systematic framework needs to be established to ensure the comprehensiveness and operability of the optimization design. Ecological function identification aims to identify ecological functions, including soil and water conservation, water conservation, biodiversity protection, etc., in order to clarify the focus and direction of ecological protection. Resource Availability Assessment aims to assess resource availability, including natural resources and human resources, etc., in order to determine the development potential and feasibility of the eco-industry. Industrial Development Potential Assessment aims to assess the development potential of eco-industries, including market demand, technical conditions, policy support, etc., in order to clarify the priority development direction of eco-industries. The policy support link aims to consider policy support, including financial, tax, land and other policy measures, in order to promote the development and optimization of eco-industries . The four aspects are interrelated and together constitute a systematic framework for the optimal design of eco-industrial layout, which serves as an important basis for guiding the optimal design of eco-industrial layout and improving the sustainability and competitiveness of eco-industries . Developing a systematic framework is one of the key steps in the study of optimal design of ecological industrial layout, which helps to clarify the objectives and

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methods of optimal design and provides important support for the sustainable development of ecological industries.

②In recent years, some positive exploration has been carried out in agriculture in terms of changing mode, adjusting structure and promoting reform, and a lot of performance has been achieved, laying a certain foundation for agricultural transformation and upgrading. However, due to the imperfection of the regional industrial modern service system and the low level of comprehensive agricultural informatization services. Particularly, aspects such as the quantity information of agricultural product cultivation and breeding, market price information, and product competition information are extremely incomplete. As a result, it becomes difficult for agricultural business entities to judge the market situation. They can only make industrial choices based on historical price information, which leads to prominent issues such as blind follow-up production, sluggish sales of products, imbalance in the supply and demand structure of agricultural products, unreasonable allocation of factors, high pressure on resources and the environment, and weak continuous growth of farmers' incomes. Frequently, this creates a vulnerable situation for farmers where they “rush to follow when prices are high and cut back when prices are low”.Therefore, in optimizing the regional industrial layout, financial support should be planned and directed, and regional resource advantages are the basis and premise for the formation of regional characteristic industries . The region in the industrial service system and the level of information technology is relatively insufficient, will lead to the industry in the market situation judgment error, and then bring economic losses. For the overall region, set clear focus and leading industries in the industrial layout. By comprehensively assessing the industrial structure and market demand in each region, targeted development strategies are formulated to ensure the effective allocation of resources and investment, while emphasizing the cultivation of strategic emerging industries to promote economic upgrading and innovation (Figures 12).

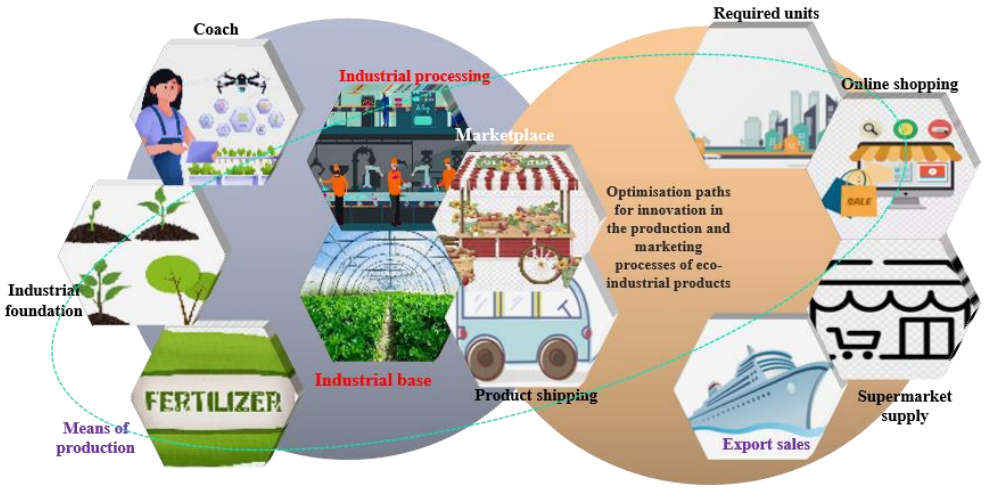

Figure 12: Path of innovation and optimization in the production and marketing process of eco-industrial products

4. Conclusions

Literature search was conducted through the CKNI and WOS databases for studies related to ecological product value realization in rural revitalisation, and 169 publications obtained were systematically analysed and reviewed. The main conclusions are as follows: (1) the number of annual publications shows an upward trend, with explosive growth after the rural revitalisation strategy was put forward in 2017, and the exploration of the conceptual connotation and level measurement of eco-industry and rural revitalisation has been deepening, but the practice and theory have failed to synergise; (2)In light of the development level of ecological industries and rural revitalization, uncover the issues inherent in rocky desertification areas. The introduction of ecological business activities under the premise of ecological protection can achieve ecological development goals, protect habitats and enhance economic benefits. Clarify the intertwined impacts of multiple factors such as economy, policy and infrastructure during the process of rural revitalization. Discover the implementation levels and obstacles of rural revitalization in different regions. Rocky desertification areas should be cognizant of their relatively poor natural conditions such as water scarcity and barren soil. Based on regional differences, develop industries in a diversified manner and embark on a path of rural revitalization that

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is suitable for rocky desertification areas.(3) In the future research, it is necessary to strengthen the cooperation of various disciplines, scientifically assess the development level of industries and rural revitalisation for different rocky desertification areas or heterogeneous areas, clarify the promotion and obstacles of ecological industries to rural revitalisation, develop suitable ecological industries according to the local conditions and improve the ecological industry chain, so that it can become an important driving force for rural revitalisation. Effective way for the benign economic development; (4) For the situation that the development system and level of ecological industry in some regions are low, it is necessary to develop pointing industries according to the actual situation of the region, to have key and leading industries, to optimise the industry and improve the level without damaging the ecosystem, which provides an important support for the sustainable development of ecological industry-driven rural revitalisation in rocky desertification areas.

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