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# A Review of Value Realization and Rural Revitalization of Eco-Products: Insights for Agroforestry Ecosystem in Karst Desertification Control

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**Abstract:** Amid global rural decline, the main approach to rural revitalization (RR) is to transform rural ecological resources into development advantages by means of ecological product value realization (EPVR). The fragility of the karst ecological environment limits the development of the karst countryside, and agroforestry is an important way to achieve the ecological protection and economic development of the karst countryside. At present, research on EPVR and RR is rapidly developing. Although there is an increasing number of publications on EPVR and RR separately, the literature on their comprehensive analysis is lacking, and how the karst agroforestry ecosystem can be improved is unclear. The objective of this is to provide an overview of the current research status and challenges of EPVR and RR in order to optimize agroforestry ecosystems in karst desertification control (KDC). This paper systematically analyzed 263 relevant articles on EPVR and RR, and the results are as follows: (1) The number of studies increased exponentially after 2017. The research has primarily focused on the relationship between EPVR and RR, as well as the EPVR and the formation mechanisms of the eco-industry and value accounting of eco-products, which account for 95.53% of the total literature. China has published the most research in this area. At the intercontinental scale, this research is mainly concentrated in East Asia, Europe, and North America. (2) The main progress and landmark achievements in the research on EPVR and RR are summarized. Four key scientific questions that need to be addressed in the future are presented. (3) The above information highlights the three key areas for improving the agroforestry ecosystem in karst desertification control (KDC): the value accounting of eco-products, EPVR, and RR. This study found that EPVR and RR can improve the karst agroforestry ecosystem and further promote rural development, providing significant insights for the overall revitalization of rural areas worldwide and the scientific control of karst desertification.

**Keywords:** eco-industry; eco-product value; rural revitalization; agroforestry; karst

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## 1. Introduction

Global sustainable development goals (SDGs) require all countries to protect the planet while promoting economic prosperity. However, ecological protection has long been recognized as limiting economic development due to a lack of understanding of the ecology–economy relationship [1]. Since the proposal of the SDGs, the practice of coordinating ecological environmental protection with socioeconomic development has increased rapidly [2].

Ecological product value realization (EPVR) is a critical channel for promoting socioeconomic development and ecological environmental protection in parallel with these

practices. It is the process of rationally exploiting and utilizing eco-products by means of policy mechanisms and market transactions under the premise of ensuring that ecosystems are not damaged and transforming ecological values into economic benefits [3]. EPVR first originated from ecosystem services practice in Western countries [4,5]. Since as early as the 1970s, EPVR in the form of eco-compensation has been incorporated into the economic decision-making process through Payment for Ecosystem Services (PES) and Compensation for Environmental Services (CES) internationally [6]. As of 2017, over 550 active PES schemes were reported to be in operation [7]. For example, around 1990, the United States and Europe began to pay more attention to the compensation of environmental services provided by farmers [8], aiming to increase the positive environmental externalities and reduce the negative ones [9,10]. The Forest Fund in Costa Rica [11], Conservation Reserve Program (CRP) and wetland mitigation banking in the United States [12,13], natural capital cost-benefit assessment project in Europe [14], ecological account in Germany and other common agricultural policies [15] are all typical cases of realizing the value of ecological products. China first proposed the concept of "eco-products" in the form of government documents in 2010 [16]. In 2017, the 19th National Congress of the Communist Party of China (CPC) proposed providing more high-quality eco-products to meet people's growing needs for a beautiful ecological environment, which promoted the rapid development of research on eco-product value realization. Some scholars have also noted that in less developed countries and regions, more attention should be paid to how to improve the living conditions of families through ecological restoration and protection [17], thereby increasing farmers' income and revitalizing the countryside. Research on eco-product value realization mainly involves various aspects, such as the implications and extension of eco-products, the assessment of eco-product value, the path and mode of eco-product value realization, the practical exploration of eco-product value realization, the analysis of typical cases, and the construction of institutional guarantees for value realization.

Rural revitalization (RR) encompasses a variety of actions taken in response to the global rural decline caused by rapid urbanization and industrialization [18], with the aim of promoting rural development and restoring rural vitality. As early as the early 1900s to 1930s, Japan formulated the Rice Law to alleviate the problem of agricultural decline. In addition, some governments, in order to promote RR, have encouraged urban affluent individuals to return to the countryside to enjoy an idyllic life through investment and policy subsidies [19]. The United States [20], the United Kingdom [21], New Zealand [22], Sweden [23], and Spain [24] have all experienced RR movements, while China's efforts in this area have been relatively recent. It was not until 2017 that the implementation of the RR strategy was proposed, followed by the Strategic Plan for RR (2018–2022) in 2018 and the Law on RR in 2021. However, this initiative is an important part of global RR, aiming to provide Chinese solutions for addressing both global RR and climate change. Since the problem of rural decline has attracted attention, scholars worldwide have conducted a series of academic studies to support RR activities. For example, in view of rural development problems such as severe population loss and huge household economic differences in rural areas of Malaysia, Rashid et al. used the framework of RR to measure the factors affecting the differentiation of rural economic performance [25], providing research support for improving the livelihoods of rural people in Malaysia and revitalizing rural economy. Japan is experiencing a global trend of an aging and shrinking population, particularly in rural areas, which has led to problems such as inadequate rural services and high cost of living [26]. In the context of the Japanese government's promulgation of a series of projects to improve rural development, Onitsuka et al. proposed focusing on the key role of training rural leaders in the implementation of projects to address the challenges facing rural areas [27]. Economic improvement is a crucial aspect of rural development, but protecting the natural ecology is equally important. Xiang et al. proposed a rural ecological revitalization model that encompasses multiple industry levels and spans various time and space scales, tailored to the three-dimensional mountain environment, natural resource endowment, and biodiversity status of Shiqiao Town in the Wuling Mountain area [28].

This model contributes to improving rural ecology and conserving biodiversity. The above research explores methods of RR according to the characteristics of regional rural development and fully considers the actual conditions of rural areas. The complex and diverse characteristics of rural geographical types and uneven economic levels require that the differences in geographical environment and rural heterogeneity be fully considered in RR, especially in karst areas with high spatial heterogeneity, high ecological background vulnerability, and lagging economic development.

The global karst region accounts for approximately 10~15% of the continental area, containing a quarter of the world's population and forming a special ecological environmental system with strong territoriality, wholeness, and comprehensiveness [29]. In this region, unreasonable human activities have caused serious ecosystem degradation, resulting in soil degradation, soil erosion, bedrock exposure, and the appearance of a desert-like landscape (also known as karst desertification) [30,31]. They have seriously impeded the sustainable development of the ecological environment and socioeconomy [32–34], directly affecting global progress in rural development. Efficient and effective ecological restoration is urgently needed to offset ecosystem degradation and ensure sustainable development in the future [35–37]. To this end, the United Nations has declared 2021–2030 the "Decade of Ecosystem Restoration" [38]. The Chinese government has implemented a series of management projects to address the problem of desertification in karst areas. Most ecological restoration programs worldwide not only aim to recover ecosystem structure and functions but also focus on improving human wellbeing [39,40]. Human and social goals are increasingly integrated into ecological restoration projects, such as poverty alleviation, EPVR, and RR. Therefore, there is a need to better understand the interaction between socio-economic systems such as EPVR and RR and ecological restoration [41–43]. However, agroforestry can pursue the maximum ecological and economic benefits in the limited site space, which is an ideal model for ecological restoration of karst rocky desertification [44,45]. Therefore, it is necessary to explore the karst agroforestry ecosystem from the perspective of EPVR and RR.

Agroforestry, a traditional land-use practice found throughout the world [46], is an intensive land management practice and a land-use system that artificially combines woody plants with multiple components of crops, pastures, and/or animals [47,48]. It covers around one billion hectares, 43% of agricultural lands globally, and involves more than 900 million people [46,49]. It is mainly distributed in Asia [46], Africa [50], and Europe [51]. Studies have shown that high-quality agroforestry composite ecosystems are not only able to provide food, timber, and other products but also ecological services [52,53]. For example, agroforestry ecosystems can increase organic carbon storage and mitigate climate change [54,55], increase biodiversity [51], mitigate the global impact of nitrogen cycle leakage in farmland [56], and improve soil health [57] and agricultural landscapes [58]. However, studies on agroforestry ecosystems in karst areas are scarce. Some scholars point out that agroforestry in the karst areas not only has positive effects on controlling soil erosion, improving the quality of the ecological environment [59], enhancing the productivity of desertification land, and protecting the diversity of soil and animals [60,61] but also promotes the revitalization of rural industries [62]. The current agroforestry research mainly focuses on the perspective of natural science. There is a lack of discussion on karst agroforestry ecosystems from the perspective of EPVR and RR.

To sum up, many studies have focused on EPVR or RR independently from a single perspective at present, while there is a lack of research that combines the two. However, some studies have found that the EPVR and RR are highly integrated in internal logic, implementation paths, and mechanisms [63], and how to promote RR in the process of EPVR is a significant research direction with the goal of modernization [63]. In addition, few scholars have conducted in-depth research on karst agroforestry from the humanistic perspectives of EPVR and RR. Therefore, this study systematically reviews the global literature on EPVR and RR over the past 20 years. The aim is to achieve the following goals: (1) describe the research progress and potential challenges of EPVR and RR, (2) explore

the revelation of EPVR and RR research on KDC agroforestry, and (3) provide important insights for the overall revitalization of rural areas in the world and the scientific control of karst desertification.

## 2. Materials and Methods

Both eco-product and RR have distinct Chinese characteristics, and the research progress on their contents by Chinese scholars holds significant academic reference value. The China National Knowledge Infrastructure (CNKI) database (https://www.cnki.net (24 October 2024)) is the most recognized academic retrieval database in China. Eco-products are similar to the "ecosystem services" that Western countries focus on [4,5] and underpin the EPVR; RR is similar to rural development in Western countries [64]. The Web of Science (WoS) core database (https://www.webofscience.com (24 October 2024)) integrates high quality from worldwide academic journals, conference papers, books, and other resources.

In conclusion, CNKI and WoS databases can meet the needs of this review. The literature search process (Figure 1) spanned from 31 December 2003 to 31 December 2023, taking "theme" as the search term and using "ecological product"/"Ecosystem service" and "rural revitalization"/"rural development" as the search words. Referring to the paradigm of the literature review (https://www.prisma-statement.org/ (24 October 2024)), we set the inclusion and exclusion criteria for the literature. The following inclusion criteria were used: (1) the selected studies need to include our search words in the title, abstract, or keywords; (2) studies must be included in WoS and CNKI databases, and (3) the research topic must be related to rural revitalization and ecological products value realization. The exclusion criteria are as follows: (1) duplicate research; (2) unavailable research; and (3) studies not written in Chinese or English. We formed a group of 3~4 people to read and screen the studies separately, consulting a professor in the field to improve the accuracy of our screening professor. A total of 665 publications were obtained. After removing duplicate publications or publications missing keywords, 429 publications remained. Then, these results were screened manually according to the theme words "ecological product value realization" and "rural revitalization", and 212 effective publications remained. Finally, to obtain secondary references from the citations, the "snowballing" method [65] was used to read the selected literature in depth. This method has been shown to be effective in identifying "hidden high quality and targeted literature" [65]. As a result of the above operations, we ultimately obtained a total of 263 valid publications, including 51 secondary references. Among them, 98 were journal articles in English, and 165 were in Chinese, including 136 journal articles, six doctoral theses, 20 master's theses, two newspapers, and one conference paper.

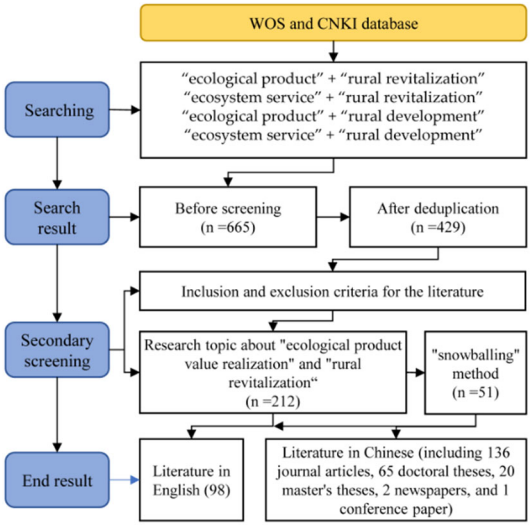



**Figure 1.** Publications search progress.

## 3. Results

### *3.1. Data Categorization*

#### 3.1.1. Annual Distribution of Publications

Between 2005 and 2023, there was a general increasing trend in the amount of research on EPVR and RR (Figure 2), which can be divided into three stages. The period before 2017 represented an embryonic and exploratory stage of research, as only a small number of years were involved in the relevant research; from 2018 to 2021, relevant publications grew rapidly, which was a rapid development stage; and exponential growth in the literature after 2022 represents a stage of diversified and practical exploration. The growing body of literature around the world indicates that EPVR and RR are receiving increasing attention from different countries and research institutes. The increase in Chinese research is particularly noticeable, which is closely related to the implementation of China's ecological civilization and rural development policies. The Report of the 19th National Congress of the Communist Party of China in 2017 proposed providing more high-quality eco-products and implementing the strategy of RR. Globally, the release of the new version of the "System of Environmental–Economic Accounting" (SEEA) in 2021, the "Opinions on Establishing and Improving the Value Realization Mechanism of Eco-product", and the "Law of the People's Republic of China on RR" have greatly contributed to the rapid development of EPVR and RR studies.

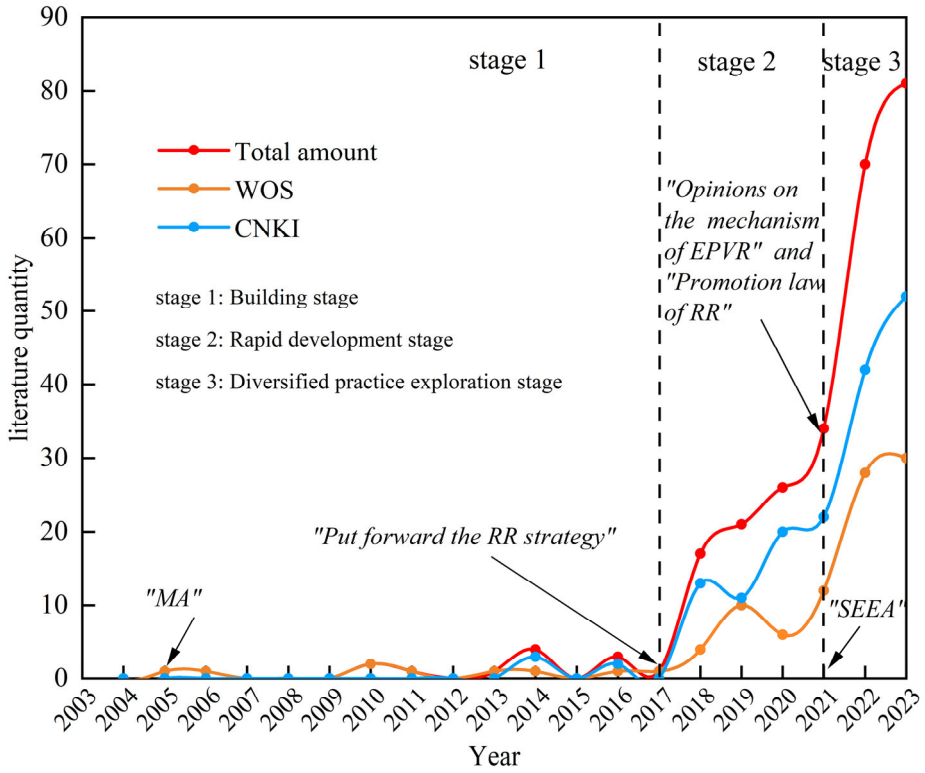



**Figure 2.** Literature annual output analysis chart.

#### 3.1.2. Research Topic Analysis

In this section, we divided and analyzed the research content from four aspects: eco-product value accounting, the mechanisms of EPVR and ecological industry formation, the driving mechanisms of EPVR to RR, and the RR model. As shown in Figure 3, the largest proportion of topics focuses on the driving mechanisms of ecological industry to RR, accounting for 35.36% of the total literature. Then, the mechanisms of EPVR and ecological industry formation (23.19%), value accounting (10.65%), and the RR model (24.33%) were identified. Studies on EPVR serve as a crucial basis for promoting the

protective development of ecological resources and rural development, having attracted significant attention from the academic community.

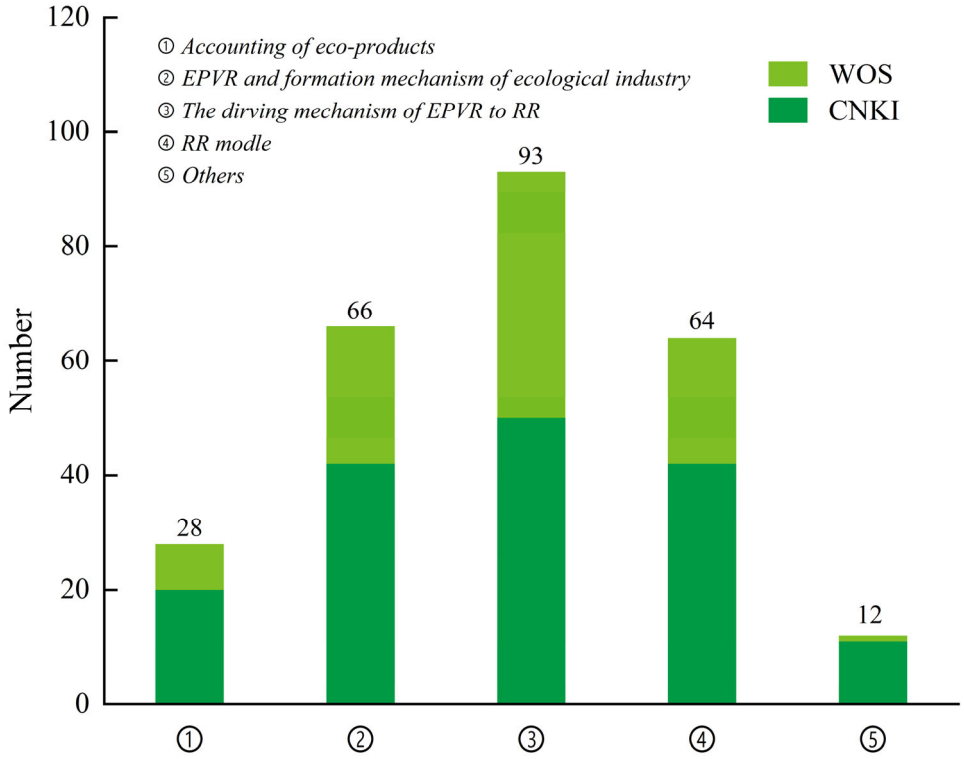



**Figure 3.** Division research content.

3.1.3. Regional Distribution of Studies in the Literature

There are obvious regional differences in EPV and RR research (Figure 4), which may be related to the regions' economic development level and policy orientation. From a global perspective, research is mainly concentrated in East Asia, North America, Europe, and other regions, while research in Africa, South America, and other regions is relatively scarce. At the national level, China has the most publications, with 213 papers, accounting for 80.99% of the total, reflecting China's emphasis on addressing rural development. The other countries include nine articles from the United States, eight from the United Kingdom, three from the Netherlands, two from Japan, and two from South Korea. This indicates that both sparsely populated developed countries in Europe and America and densely populated developing countries in East Asia with similar backgrounds to China are concerned about the issues of natural ecological environmental protection and achieving coordinated development of the human economy and society.

### *3.2. Major Developments and Landmark Achievements*

3.2.1. Eco-Product Value Accounting

In 1997, Daily and Costanza described 17 ecosystem services [4,5], which sparked a global boom in research on the assessment of ecosystem service value (ESV). As of 2020, 24 countries globally have established ecosystem accounting [6]. The accounting of eco-product value originated from the international evaluation of ESV, and the research content has primarily focused on the methods of accounting for the value of ecological products and the application of accounting results.

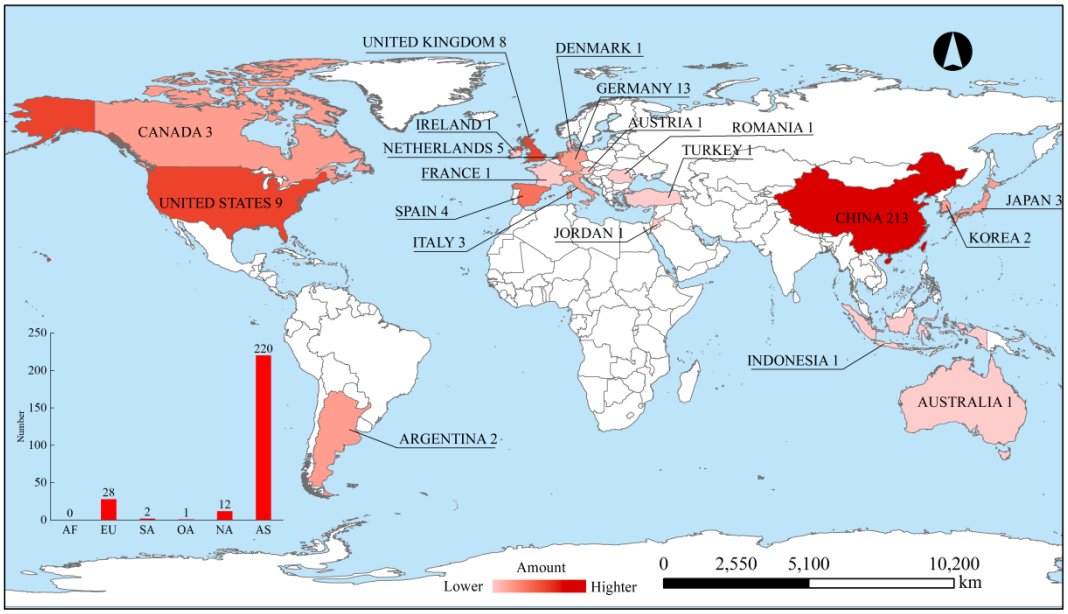



**Figure 4.** Distribution of the global literature on EPVR and RR.

The methods of equivalent factor and GEP are the most commonly used accounting methods for eco-product value assessment. The equivalent factor approach was first proposed by Xie in 2003 [66], and it was amended in 2015 [67]. Since then, the use of the equivalent factor method to account for the evolution of ESV has gradually become mainstream [68]. The equivalent factor approach is more intuitive and easier to use, with fewer data requirements and results that are easier to compare. However, it represents a macro-averaged quantity that does not fully reflect the specific ecosystem characteristics of the region. The equivalent factor approach is applicable to the valuation of ecosystem services at the regional and global scales. However, it cannot fully take into account the complexity and diversity of ecosystem services, as well as their interactions and impacts, which limits the accuracy and comprehensiveness of its assessment to a certain extent. In 2013, Ouyang first proposed the GEP method [69] to deepen the understanding of the value of ecosystem services, which was incorporated into the latest System of Environmental–Economic Accounting (SEEA) in 2021. Chinese scholars have conducted extensive empirical research on GEP involving different geographical scales at the national, provincial, state, and county levels, as well as different ecosystems such as forests, grasslands, oceans, and wetlands. Research on this topic has been conducted [6,70]. Currently, GEP has been widely recognized by society and academia, and Chinese government departments have issued more accounting guidelines and local standards, whose results can compensate for the shortcomings of the equivalent factor method, which cannot fully reflect the characteristics of specific ecosystems in the region. However, the GEP accounting method requires a large amount of data and is difficult to calculate.

#### 3.2.2. Eco-Product Value Realization and Ecological Industry Formation Mechanism EPVR

PES is widely recognized and defined as "the transfer of resources between social actors to create incentives to align individual or collective land use decisions with societal interests in natural resources management" [71]. In China, research on EPVR is relatively late in starting, and its origin can be traced back to the principle of "who develops, who protects, and who protects, who benefits" [72], as well as the practical concept of "green water and green mountains are the gold and silver mountains", which was first proposed in 2005. In 2016, the concept of "EPVR" first appeared in the Fujian Ecological Civilization Pilot Program, after which the amount of research on this topic grew rapidly, becoming a

popular multidisciplinary research topic in economics, management, ecology, geography, and other disciplines.

At present, China has conducted extensive research on EPVR, mainly from the aspects of connotation, path and mode, mechanisms, typical cases, and effectiveness assessment. The implications are mainly discussed in terms of the means of realization (i.e., the role of the government and the market) and the attainment of the goal (i.e., internalization of external effects) [73]. Qiu and Jin [74] argued that the EPVR refers to the institutional arrangement that regulates the distribution of environmental benefits and their economic benefits among the stakeholders of the eco-product supply by comprehensively applying the government, the market, and other means. On the implementation path, the government, the market, and a mixture of the government and market are the most important implementation paths. However, as implementation opinions and pilot programs for EPVR have been introduced one after another in various regions, the path of realization has become increasingly wider. The research on diversified and multisubjective EPVR paths has been deepening and has gradually become a popular research topic. In addition, around the three major paths, some scholars have refined and summarized the EPVR modes under different scenarios from different perspectives. Overall, the four major models, namely, ecological resource indicators and property rights trading, ecological restoration and value enhancement, eco-industrialization management, and eco-compensation, are being improved. In contrast to the EPVR model, the EPVR mechanism is based on the premise of maintaining the quality and stability of ecosystems through the construction of relevant policy and institutional systems to transform ecological advantages into economic advantages and improve consumer welfare. Its purpose is to enable ecological product providers and ecosystem protectors to obtain economic benefits and fundamentally solve the problem of contradictions between development and ecological environmental protection [3].

Effect Evaluation of EPVR

Evaluating the effects of EPVR is the basis for determining the status of EPVR and is an important prerequisite for determining whether or not the mechanisms of EPVR are functioning effectively or not [3]. The existing assessment methods can be divided into three types: comprehensive index evaluation methods, GEP transformation methods, and total factor productivity (TEP) methods. Comprehensive index evaluation is the most important method, and constructing an index system is its core step. Wang et al. used the comprehensive index method to quantify the effectiveness of EPVR [75]. The GEP transformation method assesses the degree of transformation of eco-product value by comparing the realized number of eco-products with GEP accounting results, with GEP accounting as the core. Lin et al. used the GEP transformation method to assess the status of the EPVR in Lishui City, Zhejiang Province [3]. The TEP method takes the resource and environmental indicators reflecting the production capacity of eco-products as inputs to TFP alongside the labor force and capital and uses parametric or DEA methods to assess their contribution to economic efficiency. Gao et al. used "green water and green mountain resources" as the input of production factors and examined the contribution of green total factor productivity to the economy [76]. Kong et al. used the value of forest eco-products as the input indicator and measured the rate of realization of the value of forest eco-products in Zhejiang Province [77,78].

Formation of Eco-Industry

The eco-industry is derived from Krutilla's idea of "ecological valuation" [79]. Research related to ecological agriculture gradually emerged in China in the late 1970s under the influence of industrial ecology theory [80]. It is an approach to constructing agricultural systems with high environmental benefits based on ecological principles [81], including professional agricultural practices such as intercropping, set cropping, crop rotation, and forest pasture [82]. In the 1990s, China began to develop ecological industries [83], which, in this period, emphasized the application of eco-technology or eco-engineering in tradi-

tional production processes; this is referred to as industrial ecology. With the proposal of eco-civilization, eco-industry has focused more on ecological industrialization; that is, the rural ecological environment is considered the main factor for industrial development, and the value of the ecological environment is maintained, enhanced, and realized through socialized production, market-oriented operation, and integrated development to ultimately protect the environment and increase farmers' income. Therefore, the implications of the eco-industry from a practical path should include industrial ecology and ecological industrialization. In recent years, the study of the ecological industry has received increasing attention from academics, and the EPVR model [84], the "two mountains" model [85], and eco-industrialization and industrial ecology models [86] have been proposed. The coordinated development of industrial ecology and eco-industrialization [87], "green water and green mountains are golden silver mountains" [88], and other eco-industrial practice paths have been summarized. Other scholars have also extensively explored the eco-industrial chain [89], eco-industrial value chain [90], and eco-industrial park [91,92]. In karst areas, soil and water conservation programs provide the most basic material foundation and spatial guarantees for eco-industrialization and promote the formation of eco-industries.

#### 3.2.3. Driving Mechanisms of EPVR for RR

##### Rural Industrial Revitalization

Industrial revitalization is the foundation of RR, and other goals of RR can only be achieved by achieving industrial prosperity and improving the income level of rural residents [93]. As early as the beginning of the 20th century to the 1930s, in response to the problem of agricultural decline, Japan enacted the "Rice Law" to stabilize the rice market and protect the interests of farmers. In the 1990s, Japan implemented the rural industry revitalization path of "one village, one product" [94] and "six industrializations" [95]. Drawing on Japan's experience, South Korea launched the top-down "New Village Movement" [96] to promote the development of rural industries. With its resource endowment and scientific and technological advantages, the United States has developed a specialized agricultural industry development model and has become the most powerful agricultural entity in the world [97].

Although research on the revitalization of rural industries in China started late, existing research has focused mainly on the ecological forest industry [98], ecological agriculture [99], eco-tourism [100], and the integration of primary, secondary and tertiary industries to develop innovative ecological industries [101] and other directions have explored the revitalization of rural industries. In karst areas, a series of suitable rural ecological industry models have been explored [102]. In particular, karst agroforestry ecological agriculture has attracted increasing attention and adoption by scholars [103,104]. However, the current agroforestry industry still has problems, such as a single structure and a low industrialization level [105,106].

##### Rural Ecological Revitalization

Ecological revitalization is a powerful measure for improving the rural ecological environment, an inherent requirement for building a beautiful China, and an inevitable choice for implementing an ecological civilization strategy. The term "rural ecological revitalization" emerged with the Chinese government's RR strategy, and its essence is close to that of foreign research on rural ecological environmental protection and ecological construction. As early as the late 19th and early 20th centuries, the idyllic countryside became a destination for some Europeans [107]. Scholars have proposed the concept of "eco-villages" [108,109] as a livable lifestyle model that achieves harmonious coexistence between humans and nature. The "New Village Movement" [110] launched in the 1970s in South Korea and the construction of new villages [111] launched in the 1980s in the Federal Republic of Germany are both useful attempts to protect the rural ecological environment and improve the living environment.

Since China proposed its RR strategy in 2017, research on rural ecological revitalization has developed rapidly. Current research mainly focuses on the following two points: first, the theory and case analysis of rural ecological revitalization, and second, research on the dilemmas and paths of rural ecological revitalization. At the theoretical and practical levels, predecessors have mainly studied the theory, value, and practice of rural ecological revitalization from the perspectives of the concepts of "life community" [112], ecological security [113], and integrity [114] Research suggests that rural ecological revitalization should be promoted with the holistic and systematic thinking of the "life community" [112,114]. In terms of dilemmas and paths, Liu et al. [115]. Posited that the key to ecological revitalization is to ensure ecological security through institutions, enhance farmer awareness of ecological protection, promote the realization of the value of eco-products, and vigorously develop ecological industries.

Rural Cultural Revitalization

Although there are few foreign studies on the topic of rural cultural revitalization, rural culture has always been a popular topic for scholars. Rural culture serves as both the endogenous power and a vital link in rural development [116]. Farmers are the primary drivers of village development, and village culture can only be constructed by cultivating farmers' ideology and lifestyle, strengthening their education in modern knowledge, and promoting villages towards modernization [96]. Some scholars have also explored the strategies and methods of village culture construction in terms of institutions and laws [117], the plurality and sustainability of vernacular cultures [118], safe and stable development environments [119], and people's spiritual development [120].

China's research on rural culture started late, and Li [121] posited that rural culture is expressed in different forms, such as values, social psychology, and behavior. For example, ancient Chinese farmers utilized the symbiotic relationships between organisms to develop a multilevel ecological agricultural system, which resulted in the formation of excellent traditional ecological farming techniques, including "intercropping", "set cropping", and mulberry-based fishponds [122]. With the introduction of the RR strategy, the study of rural cultural revitalization has seen unprecedented development. Scholars have explored the practical dilemmas and realization paths of rural cultural revitalization from different perspectives [123]. While protecting and inheriting fine-farming culture and strengthening the deep integration of rural cultural industry and tourism are vital to rural cultural revitalization [124], there are fewer related issues.

RR Level Evaluation

Reasonable evaluation of RR is fundamental to effectively solving the outstanding problems in the development progress of RR strategies, compensating for the shortcomings of reality, and addressing the major problems [125]. Cloke [126] constructed a RR index to assess the level of rural development in the 1970s [127,128], but this index has poor practicality because it uses the social representation method [129]. Terluin [130] argued that rural performance differences are the main factors affecting changes in RR by measuring population, territorial dynamics, and the globalization process. On this basis, some scholars have assessed the current state of economic development at the regional scale based on economic, human, social, cultural, and environmental factors, and the focus of related research has shifted from single-issue investigations to comprehensive analyses of multiple issues [131,132].

China's evaluation research on RR has primarily focused on the construction of indicator systems and evaluation methods [133,134]. The indicator system is mostly built on the basis of the five elements of RR, and the evaluation methods mainly include factor analysis [134], hierarchical analysis [135], the entropy value method [136], and the entropy weight TOPSIS method [137]. Chinese scholars have mainly used the entropy value method to assess RR at different geographical scales based on the five-factor RR indicator system. For example, Xu et al. constructed 30 specific indicators containing five subsystems from

a national perspective and evaluated RR in China using the entropy method [138]. Wang et al. used the same method to asses RR in 30 provinces in China [139] and analyzed the RR status of eight comprehensive economic zones [140]. Some scholars have also measured RR from the perspective of the digital economy [141] and green development [142]. The effectiveness of RR implementation in Guizhou Province based on the context of fragile karst ecosystems has not been evaluated at present.

#### 3.2.4. RR Model

RR Model Driven by External Forces

From a top-down/downscaling perspective, the rise in RR in China can be seen as the result of the state's spatial selection, orienting rural areas to overcome the rural decline crisis [143–145]. Its essence is that the Chinese central government has made top-level designs at the policy level based on the actual situation of rural modernization in the global modernization process, calling for capital to flow to unbalanced and insufficient development areas [146]. The process is mainly reflected in local governments, which have developed their own specific RR projects in response to the national strategy. However, the top-down paradigm in academia emphasizes the significant role of extra-local resources, and rural development requires external assistance to drive them toward modernization [147]. At the same time, these scholars also emphasize the impact of top-down planning on rural development [148]. They see RR as the diffusion of modernization from urban to rural areas and posit that RR should follow the paradigm of rural modernization [149]. The goals of modernization are closely related to industrialization, urbanization, and national construction projects [150–153]. Therefore, they advocate that rural development can be promoted through industrialization and urbanization with the support of the state [154,155]. The state can facilitate rural self-development or take a direct role in development.

RR Model Driven by Internal Forces

For a long time, institutional constraints have positioned farmers as passive subjects Policy measures based on the urban perspective focus on external resource input in rural construction and apply urban development standards to formulate rural management plans. This perspective made farmers passive product producers and labor suppliers, lacking the right to rural management. Ultimately, the interests, habits, and values established by external managers conflict with those of farmers in the traditional rural environment and are contrary to each other. Once the actions of urban resource inputting stop, the village returns to poor management. Therefore, Ma and Fan [126] proposed the concept of "bottom-up urbanization" to describe the spontaneous development of rural China. This concept represents an endogenous RR model that focuses on the participation, initiative, and development of regional characteristics of rural residents. Usually, the remaining villagers in the countryside are mostly older, less educated and less aware of environmental protection, and have an insufficient understanding of the value of the countryside. They often lack the ability to start their own businesses and primarily engage in farming. In this case, RR needs to address the endogenous needs of farmers and cultivate their self-development capacity with the support of external objects [156]. When implementing RR, local villagers are invited to participate in the whole process, and they are taught professional knowledge and skills for self-employment. Through this form of public participation, villagers can update their knowledge, rethink the once neglected value of their hometown, gradually change their outdated conceptualization that "the city is better than rural areas", become less dependent on "modernization", and stimulate the endogenous driving force of RR. In summary, while broad public policy and planning initiatives are necessary in some cases, the success of most communities will ultimately depend more on the actions of the people who live there [157,158].

## 4. Discussion

The above study introduces the research history of EPVR and RR in terms of annual changes in the literature, theme distributions, and regional distributions. We summarized the progress and landmark achievements in recent years in the areas of value accounting, value realization, and ecological industry formation mechanisms, as well as the driving mechanisms of EPVR on RR and RR models. On this basis, four key scientific issues need to be addressed.

### *4.1. Key Problems to Be Solved*

#### 4.1.1. Actively Exploring EPVR's Innovative Models and New Realization Paths to Improve Their Realization Rate

Some regions of the world have carried out practical exploration of EPVR, mainly focusing on ecological industry development, resource and environmental rights trading, eco-compensation, market trading, and other models, and achieved remarkable results. However, the existing EPVR model is not suitable for all types of ecological products and lacks diversified and integrated models. For example, Lishui City realizes most of the value of ecological products by using the market transaction model, but this model cannot effectively support the realization of the value of regulatory service products, and the value of ecological products realized by this model is only 2.39%. The government eco-compensation model mainly supports the value realization of regulated service products, but the value of ecological products realized through this model only accounts for 4.16% of the total value realization [3], and the efficiency of product value realization is low. Therefore, we should continue to encourage and guide local governments to actively explore EPVR in the future. We will continue to explore new paths and innovative models, strengthen the refining and summary of existing experience models, form diversified and integrated models, and promote their application.

#### 4.1.2. Exploring the Driving Mechanisms of EPVR on RR

Scholars have conducted preliminary research on the synergistic development model of EPVR and RR in China from the perspectives of ecological protection compensation, ecological product management and development, and "ecology+" industrialization [76,159]. However, problems such as immature models and imperfect mechanisms still exist in EPVR [140]. Proposing operable synergistic modes and mechanisms to boost the smooth realization of RR goals in the new development stage is a major practical problem that urgently needs to be solved [76]. In the future, we should develop eco-agriculture with science and technological innovation as the main theme, develop the agricultural product processing industry with green transformation as the main theme, develop rural characteristic industries with brand building as the main theme, develop the rural eco-tourism industry with quality enhancement as the main theme, develop the rural carbon sink industry around the main theme of facilitating market trading, and build the whole rural industrial chain around the main theme of "eco+" [159]. The whole industrial chain of the countryside is constructed with the main theme of "ecology plus" [160], and the synergistic development of the EPVR and RR is achieved through ecological industrialization and industrial ecology.

#### 4.1.3. Constructing a Village-Scale Evaluation System of RR Level

Accurate measurement of RR is the basis for understanding the degree of regional development and is a significant prerequisite for guiding government policy formulation. Chinese scholars have explored a variety of RR evaluation methods and have measured RR at different geographic scales, such as national, provincial, and county scales [138,139]. However, village and town-level RR measurements are lacking. With large spatial heterogeneity in karst areas, large-scale evaluation methods may not accurately reflect the actual situation of karst rural development. Therefore, a small-scale evaluation system suitable for

ecologically fragile karst areas should be constructed based on local realities to stimulate the endogenous impetus of RR and promote the coordinated development of rural areas.

#### 4.1.4. Exploring RR Models Based on EPVR Paths

Rural decline is a common problem faced globally and has received attention from countries in Europe, as well as from the United States, Japan, Korea, and China, which have formulated a series of policies and measures to promote RR. However, as China has a vast territory and the geographical types of villages are complex and diverse, RR should fully take into account the characteristics of geographical differences and rural heterogeneity [111]. Currently, there are abundant studies on EPVR and RR from a single perspective, but there is a lack of research on RR models based on EPVR in the countryside, while EPVR has fostered the green kinetic energy of RR through ecological industrialization and enhanced the "green" undertone through industrial ecology [157]. At the same time, EPVR can increase income and provide financial security for RR. Therefore, we should fully utilize the advantages of rural ecological resources to explore RR models based on the path of EPVR. Agroforestry is an important resource for rural development in KCD areas, and exploring the RR model based on the path of EPVR of agroforestry is of great practical significance for promoting comprehensive rural development and realizing common prosperity in KCD areas.

### *4.2. Enlightenment for Agroforestry Ecosystem*

#### 4.2.1. Constructing an Accounting Framework for Agroforestry Eco-Products in KDC

Agroforestry is an ecosystem that integrates agroforestry management, which is an important component of the terrestrial ecosystem. While it shares similarities with agricultural and forest ecosystems, it also possesses unique characteristics. Its value calculation differs from that of the total value of a single eco-product in forest ecosystems and involves a very complex process [161]. High-quality agroforestry ecosystems not only provide food, timber, and other products but also have other ES functions, such as inhibiting soil erosion, controlling pests and diseases, protecting biodiversity, and improving the ecological environment [53,162]. Therefore, agroforestry is considered a "win–win" land use system. The agroforestry systems developed in KDC can improve the efficiency of land use while providing ecosystem services to meet the needs of diverse food intake and a beautiful ecological environment. The correct accounting of ecosystem service value is the basis for understanding the ecosystem quality of the agroforestry ecosystem, but the accounting procedures are lacking. The Accounting Procedures for the Total Value of Terrestrial Ecosystem and the Accounting Procedures for Forest Ecosystem Services have been publicly released. Therefore, the future should be based on the characteristics of agroforestry ecological products, with reference to the above standards, to establish the total value of agroforestry ecosystem accounting procedures. At the same time, due to the difference in the natural environment and human environment between the karst area and non-karst area, the factor of rocky desertification should be considered when constructing the value accounting rules of karst agroforestry products.

#### 4.2.2. Enlightenment of EPVR for the Agroforestry Ecosystem in KDC

Agroforestry is a new eco-industry model that differs from traditional agriculture [163], which can improve the ecological environment while improving economic efficiency. Ambiguous ownership of land and woodland [164,165] and lack of support funds [166] are the main human factors hindering the development of agroforestry. The improvement of the EPVR path and mechanism, such as the right confirmation of ecological resources, the improvement of the eco-compensation mechanism, and the implementation of ecosystem service payment projects, can alleviate the above human factors' obstacles to the development of agroforestry to a certain extent, so as to improve the agroforestry ecosystem. Therefore, this section discusses the enlightenment of EPVR to the KDC agroforestry ecosystem from the aspects of rights confirmation registration of ecological resources,

eco-compensation, and ecosystem service payment. Therefore, this section discusses the insights gained from EPVR regarding the KDC agroforestry ecosystem, focusing on the aspects of rights confirmation registration of ecological resources, eco-compensation, and ecosystem service payment.

Under the basic premise that the ecological resources are collectively owned and remain unchanged, rights registration for agroforestry ecological resources should be carried out to assess the background of agroforestry ecological resources (scale, quality grade, spatial distribution pattern, development, utilization, etc.), and the main property rights of agroforestry ecological resources assets should be further clarified and defined. At the same time, under the premise of clearly defined property rights, governments at all levels should be clear about the management authority of ecological resources such as land and forest resources; improving the mechanism of "co-governance, co-management and sharing" of ecological resource assets; and promoting the efficient and intensive use of ecological resource assets [167]. When the relationship between ownership and responsibility of the ecological resources of agroforestry is determined, the ecological resources of agroforestry can be managed in the market according to the general law of the commodity market so as to transform the physical, ecological resources of agroforestry into ecological assets of value and carry out transactions, create additional economic income for farmers, and improve the adoption rate of agroforestry. KDC agroforestry also has the problem of fuzzy ownership and responsibility. Some studies have shown that the profitability of forestry investment and the acquisition of ecological property rights, such as the income and rights of ecological products, are the main motives for farmers to invest in forestry [168]. Therefore, it is necessary to establish a clear property rights system for KDC agroforestry and forestry ecological resources and carry out a reasonable structure of agroforestry and forestry ecological property rights trading pilot in the KDC region so that rural farmers can realize the ecological forest benefits of agroforestry and forestry through the ecological market. Expressing the ecological value of agroforestry and forestry encourages farmers to invest in planting trees on karst slope farmland, which is an effective way to improve the karst agroforestry and forestry ecosystem for sustainable development.

Eco-compensation is a Chinese policy, similar to the pay for ecosystem services/pay for environmental services policy in Western countries. They are both conservation strategies designed to provide financial incentives to farmers to manage their land and provide ecological benefits without compromising their livelihoods [169]. It is essential to promote ecologically intensive agriculture to reduce the environmental impact of the agricultural sector [170]. Agroforestry is one of the agricultural policy measures to increase the ecological benefits of farmland [171]. Studies have shown that ensuring farmers' livelihoods through ecological compensation can effectively realize the value of forest carbon sink [172]. Although agroforestry has been promoted among farmers worldwide, its uptake is not satisfactory and ecological compensation is needed to increase the economic attractiveness of agroforestry to farmers [173]. However, karst rocky desertification is usually accompanied by poverty. Local farmers' excessive dependence on traditional agricultural production methods and unreasonable ecological compensation standards for agroforestry lead to a lack of motivation for farmers to participate in agroforestry [174], which limits the promotion of agroforestry. However, women, the elderly, and large families have a positive impact on ecological compensation [175]. It can be seen that the key to improving the agroforestry ecosystem is to establish a reasonable compensation standard and stimulate farmers to participate in agroforestry planting in karst areas. In the formulation of ecological compensation standards for karst agroforestry ecosystems, policy implementers focus on communicating with local farmers and enhancing awareness of ecological protection and compensation within agroforestry ecosystems to improve people's environmental protection awareness and willingness to accept agroforestry ecosystems. They were differentiated based on regional development, using the value of karst agroforestry ecosystem services as the upper limit for compensation [176,177]. This approach aims to compensate for the maximum benefits given up by choosing agroforestry planting [178,179], thereby

establishing differentiated ecological compensation standards. At the same time, attention should be paid to the role PES plays in promoting women's economic empowerment [180].

#### 4.2.3. Enlightenment of RR for Agroforestry Ecosystems in KDC

As the material basis for realizing the value of ecological products, ecosystem services support the supply of products and regulate the supply of service products and cultural service products; these ecological products are closely related to industrial revitalization, ecological revitalization, and cultural revitalization in rural revitalization. Studies have shown that industrial revitalization, ecological revitalization, and cultural revitalization promote the supply, regulation, and support of ecological services as well as the continuous supply of cultural services, respectively [181,182]. Therefore, from the three aspects of rural industry, ecology, and culture, the following is a comprehensive study of the value realization of ecological products and rural revitalization, aiming to gain insights into the improvement of the karst agroforestry ecosystem.

The formation of an agroforestry ecological industry. Agroforestry is a land use method with both ecological and economic benefits, which has the comprehensive benefits of promoting ecological environment restoration, sustainable utilization of soil resources, and social and economic development [183,184]. As the preferred method for agricultural and rural economic development in ecologically fragile regions, it has been applied and popularized in karst rocky desertification areas [185]. However, at present, there is no certain industrial scale, and the ecological and economic benefits are seriously limited. Moreover, under the influence of the traditional management mode of land abandonment and intensification, the economic value is over-emphasized while the protection of the agroforestry ecosystem is ignored [186,187]. Different from the traditional industrial development model, the ecological industry includes ecological industrialization and industrial ecology [188]. Industrial ecologization mimics natural ecosystems to build industrial ecosystems and minimize the interference of industrial operations in the ecological environment [189], so as to improve the quality of karst agroforestry ecosystems and provide diversified ecosystem services. Ecological industrialization, on the other hand, transforms the advantages of karst natural resources into advantages of economic development, increases the supply of ecological products and economic income in karst villages, solves the problems of insufficient funds of farmers and poor mobility of production factors [190], and expands the sources of funds for ecological restoration, providing more possibilities for further improving the agroforestry ecosystem. Therefore, it is necessary to form an ecological industry development model of the mixed agroforestry ecosystem in order to improve the quality of the mixed agroforestry ecosystem and give full play to its comprehensive benefits.

Rural ecological landscape management and development. Spatial or temporal combinations of trees and crops allow for greater structural and functional complexity in agroforestry [191], which not only increases the efficiency of nutrient, light, and water capture and use and improves food and nutrition security, but also forms valuable cultural landscapes and reduces environmental degradation [192]. Agroforestry is key to sustainable landscape management and has the potential to protect and enhance landscape biodiversity [193]. In addition, agroforestry in karst rocky desertification areas can significantly improve ecological landscape quality [59]. However, agroforestry landscapes in general have complex dynamics involving governance institutions, actors, and networks that interact across time and space scales [194] and are highly vulnerable to impacts and disruptions. It is highly important to manage the agroforestry landscape in karst rocky desertification areas. Rolo et al. [195] study revealed that the decline of agroforestry landscapes throughout Europe was mainly due to its poor economic performance. The sustainability of agroforestry landscapes should be promoted by fully responding to farmers' social expectations of agroforestry landscapes [196]. Therefore, karst areas need to change the mode of rural landscape management and development and develop cultural services for agroforestry landscapes through ecotourism, underforest health, and other means. On the one hand, reducing the risk of family livelihood and rural problems caused by excessive

dependence on services provided by mixed agricultural and forestry landscapes can be achieved [197]. By increasing the economic income and spiritual enjoyment brought by the agroforestry landscape to the local residents, the expectations of farmers can be met, thereby increasing the sustainability of the mixed forestry landscape and improving agroforestry.

Ecological knowledge and technology promotion and popularization. Although agroforestry ecosystems provide a variety of ecosystem services that help sustain crop production, improve farmers' livelihoods, and conserve biodiversity [191], they can also lead to damage and antagonistic effects [198,199]. This damage is due to farmers' inadequate understanding of ecosystem services and lack of ecological knowledge, resulting in an increasingly prominent problem of impaired ecological functions of agroforestry [200]. At present, there are serious environmental stresses in karst areas around the world. For example, in the Puglia region of southern Italy, widespread quarries and stone clearing activities have significantly altered the original karst landscape, causing partial or total destruction of natural caves [201]. The improvement rate of population quality in karst rocky desertification areas in China lags behind the national average rate [202], and the low scientific and cultural quality of the population seriously restricts the sustainable development of the karst eco-economic system [32], and the contradiction between man and land is increasingly acute. The popularization of ecological knowledge and technology through education and training can effectively improve farmers' understanding of agroforestry ecosystem services and their rational utilization ability [203], thus contributing to the sustainable and healthy supply of agroforestry ecosystem services in karst regions and the revitalization of rural ecology.

### *4.3. Limitations*

In this paper, only the WoS and CNKI databases were used, not the Spring and Scopus databases; therefore, the search results may be biased. In addition, there is a bias in the selection of publications as well as subjectivity in the interpretation of the classification of research topics and the key scientific questions to be addressed.

## 5. Conclusions

Agroforestry ecosystems are important ecosystems in karst areas. They can provide supply products, such as fruit and grain; regulation service products, such as soil conservation and water conservation; and cultural service products, such as agroforestry tourism, leisure, and esthetics, demonstrating their rich value. The value realization path of ecological products, such as ecological industry management and development, ecological compensation, and ecological rights and interests trading, can, to a certain extent, transform the ecological value hidden in agroforestry into economic value, thus promoting the revitalization of rural industry, ecology, and culture, broadening rural farmers' livelihood mode, enhancing their awareness of ecological environmental protection, and increasing rural capital income (Figure 5). Agroforestry is an important ecological resource in karst regions, providing a large number of material products and ecological services for RR. Therefore, it is necessary to improve the agroforestry ecosystem based on EPRV and RR. We conducted a systematic literature review by collecting, organizing, and screening 263 publications from the CNKI and WoS databases and reached the following conclusions:

(1) In terms of the annual distribution of literature, there has been a rapid growth trend since 2017. The research stage was divided into a germination period (2000–2017), a development period (2017–2021), and a diversification period (2021–2023).
(2) In terms of research themes, relevant studies have focused mainly on EPRV and the formation mechanisms of ecological industry, the driving mechanisms of EPVR on RR, and the accounting of ecological product value, accounting for 95.53% of the total publications. The research regions are mainly distributed in East Asia, Europe, and North America, among which China is the region with the most relevant research.
(3) According to the results of the systematic review of related studies, we propose four key scientific issues that need to be solved in the future: actively exploring

EPVR's innovative models and new realization paths to improve their realization rate; exploring the driving mechanisms of EPVR on RR; constructing a village-scale evaluation system of RR level; and exploring RR models based on EPVR paths.

(4) Based on the review results, this study provides insights into how global EPVR and RR improve karst agroforestry ecosystems from aspects such as ecological resource ownership, eco-compensation, payment for ecosystem services, formation of agroforestry industries, management of rural ecological landscapes, and cultivation of ecological knowledge.

(5) EPVR and RR can improve the karst agroforestry ecosystem and further promote rural development.

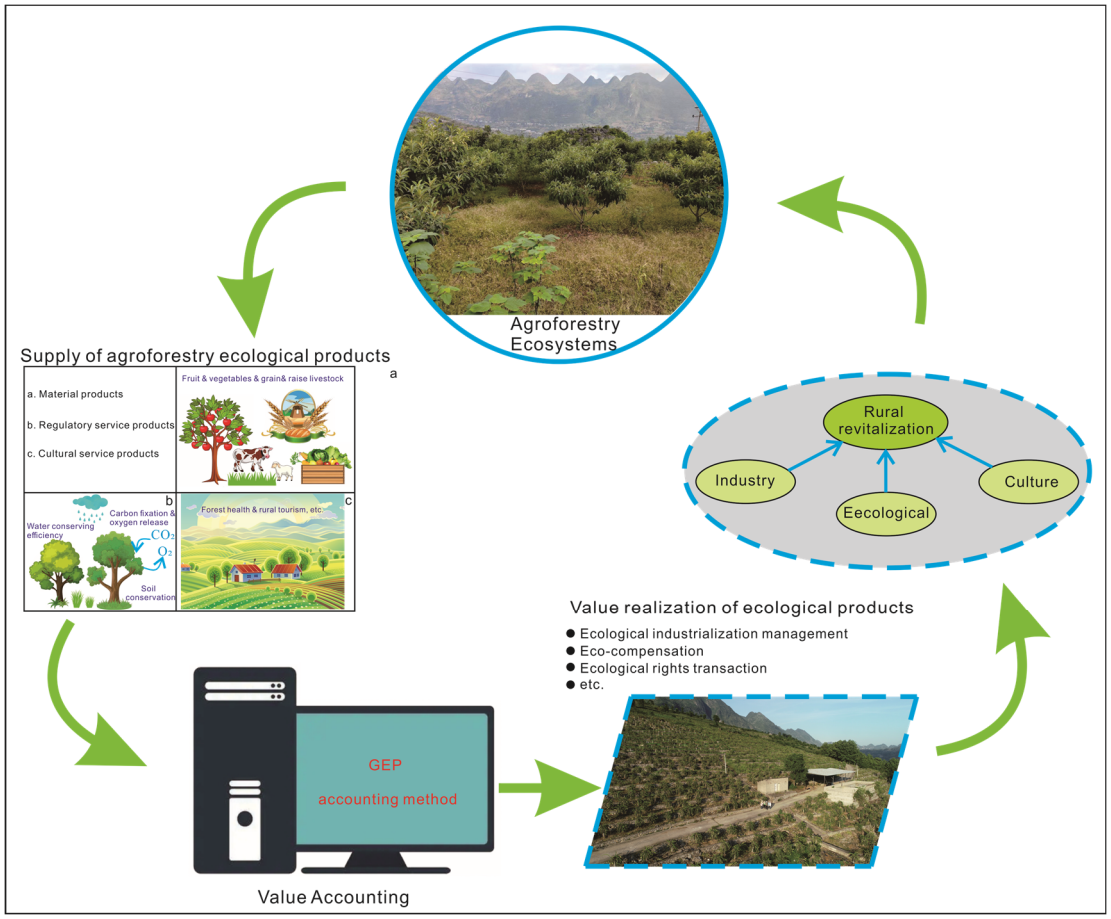



**Figure 5.** Relationship between agroforestry eco-product value realization and RR.

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