Main Developments and Landmark Achievements of Ecological Product

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"Ecological products" is a unique Chinese concept, which is similar in nature to the ecosystem services that developed countries are concerned about. The restoration of the ecological environment in rocky desertification areas and economic development go hand in hand. With the support of the national policies from the "Ninth Five-Year Plan" to the "Thirteenth Five-Year Plan", the related ecological industries and products derived from the control of rocky desertification in karst areas continue to emerge. It not only restrains and repairs the development of rocky desertification but also produces a higher regional economic value than the replaced industry, which has practical significance for targeted poverty alleviation and rural revitalization in rocky desertification areas.

Keywords: eco-products ; karst rocky desertification control ; value-realization

1. Introduction

South China Karst is an area with the largest exposure area of the three karst concentration areas in the world. Its special natural environment leads to a fragile and sensitive ecosystem [1][2][3]. Coupled with the unreasonable social and economic activities of human beings, the contradiction between man and land is prominent, and different degrees of land degradation—e.g., rocky desertification—have appeared. The problem of rocky desertification is called "Ecological cancer", which causes the dual poverty of ecology and economy in the karst area, which is the key and most difficult point of ecological civilization construction and the main battlefield of National Poverty Alleviation [4][5].

The ecoindustrial governance model is a win-win model between rocky desertification control and regional economic development in karst areas. From the Ninth Five-Year plan to the 13th Five-Year Plan, the Chinese government has continuously provided policy support, technological innovation, and financial guarantee for karst areas. The report of the 18th CPC National Congress also clearly pointed out the need to vigorously promote the construction of ecological civilization, enhance the production capacity of ecological products and promote the comprehensive management of rocky desertification [6][7][8]. To seek the healthy development of ecology and economy in karst areas, many scientific researchers have explored ecological industries suitable for local rocky desertification control and economic development in combination with the fragile karst environment and local reality and formed an ecological industry technology and promotion model for comprehensive rocky desertification control. In the governance model, the ecological industry model considers socio-economic development and environmental restoration [9][10].

2. Main Developments and Landmark Achievements

2.1. Basic Theory

2.1.1. Low Added Value of Ecological Products

"Ecological products" is a unique Chinese concept, which is similar in nature to the ecosystem services that developed countries are concerned about [11][12]. Western developed industrialized countries faced ecological environment problems earlier than us and realized the importance of natural systems to provide comprehensive services. In 2010, China put forward the concept of ecological products for the first time in the "National Main Function Area Planning (Guo Fa [2010] No. 46)", which is a core concept of ecological civilization construction. The general development process of ecological product value realization from concept to practice is shown in **Table 1**. Therefore, this paper classifies the development of ecological products, including the integration of production and sales of ecological products from production to market. Ecological products can come from original ecosystems or from ecosystems that have restored their service functions after inputting human labor and corresponding social material resources [13]. Therefore, ecological derivatives appearing after karst rocky desertification control are also ecological products. The fragile karst environment has high requirements for human activities [14], and developing ecological industries is the only way to consolidate the achievements of rocky desertification control. In the early stage of ecological industry development, agricultural development is the focus, so there are more primary ecological products, the added value of products is low and the economic benefits brought by products are also low. Reasonably expanding the supply capacity of ecological products and improving the ecological industrial structure in the karst area are the top priorities for obtaining higher economic benefits.

Table 1. Development of Eco-Product Concepts in Chinese Policy Papers from 2010–2021. Data Sources: http://www.gov.cn (accessed on 8 February 2022).

Years	Literature	Main Content
2010	National main functional area planning	The concept of ecological products was proposed for the first time, emphasizing that ecological products are the function of ecosystems to provide ecological regulation
2012	Report of the 18th National Congress of the Communist Party of China	Emphasis on enhancing productivity of ecological products
2015	"Thirteenth Five-Year Plan"	Emphasis on the provision of higher quality ecological products
2016	National Ecological Protection "Thirteenth Five-Year Plan" Outline	Emphasis on expanding the supply of ecological products and further clarifying the specific connotation of ecological products
2016	Opinions on Improving the Ecological Protection Compensation Mechanism	Two main supply modes of ecological products are clarified, namely, ecological compensation and market transactions
2016	Implementation Plan of the National Ecological Civilization Pilot Zone (Fujian)	The practical exploration of ecological product value realization will start in the main ecological civilization pilot area
2017	Report of the 19th National Congress of the Communist Party of China	The national goal of supplying ecological products was clarified
2018	Speech by General Secretary Xi Jinping at the Symposium on Deepening the Development of the Yangtze River Economic Belt	Clarified the direction and specific requirements of the path to realize the value of ecological products
2019	Opinions on supporting Zhejiang Lishui to carry out the pilot project of ecological product value realization mechanism	Propose the concept of ecological product value realization mechanism and start the special practice exploration at the prefecture level
2021	Opinions on Establishing and Improving the Value Realization Mechanism of Ecological Products	Establish ecological product investigation and monitoring mechanism, value evaluation mechanism, management and development mechanism, protection compensation mechanism, value realization guarantee and promotion mechanism

2.1.2. Ecological Products Have Dual Properties

The production process of ecological products condenses general and undifferentiated human labor. It needs market exchange to realize its value. From the perspective of demand, high-quality ecological products are indispensable for the normal life of human beings, but most of the products have the characteristics of being regional, difficult to measure, partitioned and invisible, and it is impossible to buy and sell them in the market like general material commodities [15]. The relationship between ecological products and basic human values is a special one. Therefore, ecological products not only have their own ecological attributes but also unique economic and social attributes. The diversity of its inherent attributes determines that the research on ecological products should be diversified, and three-dimensional, and comprehensive research should be conducted from multiple angles and levels [16]. Ecological products improve the utilization rate of resources and labor productivity. Ecological products are designed and transformed according to the principle of "integration, coordination, recycling and regeneration", including the transformation of the energy structure, such as the development and utilization of solar energy, natural energy and bioenergy and the effective utilization of mineral energy [17]. The realization of ecological value, on the one hand, reflects the principle of high-quality production at a better price and, on the other hand, implements the economicalization of ecological benefits, thereby promoting the environmental protection of the enterprise from the social welfare type to the economic profit type, so it has invested more manpower. The market prices of materials and technology are slightly higher than that of general commodities. This may be at a disadvantage in the competition of similar general commodities. In this case, it is necessary to find more competitive ecological products.

2.2. Pattern Construction

2.2.1. Various Modes of Ecological Governance of Karst Rocky Desertification

The rocky desertification areas in Guizhou have prominent contradictions between people and land (mainly due to large population and large proportion of agricultural population). They are generally faced with three major problems: economic poverty (lack of food and money), poor living environment conditions (low vegetation coverage, difficulty in sourcing drinking water for people and livestock, frequent karst drought and flood disasters, etc.) and insufficient potential for regional sustainable development (single rural industrial structure, lack of alternative industries and new economic growth points) [18][19]. Therefore, the rocky desertification control model should be explored from the aspects of different karst landform types, different levels of rocky desertification, different rocky desertification types and different site conditions. Moreover, on the basis of following the principle of species adaptability, the principle of combining long- and short-term, the principle of hierarchy and sequence, the principle of ecological compensation and the principle of market orientation, the coordination and unity of ecological benefits, economic benefits and social benefits is sought after [20]. In recent years, various scientific research institutions and local forestry, agriculture, water conservancy, animal husbandry and other departments have made technological breakthroughs in the implementation of key national scientific and technological projects, namely, the Yangtze River improvement project and the Pearl River improvement project. In the field of the comprehensive control of rocky desertification, many models and application technology systems with practical application value have been proposed, which play an important guiding role in the comprehensive control of rocky desertification in Guizhou [7][20]. Based on the key problems of rocky desertification and the technical measures taken by the control model, the constructed rocky desertification control models include seven categories: a vegetation restoration model of forest and grass [9], a soil and water conservation model [10], a development model of herbivorous animal husbandry [21], an ecological agricultural model [18], a tourism mode of ecological reserves [22], a comprehensive governance model [23] and an ecological migration model [24]. Karst rocky desertification control has established different control models from different angles, but the landform and geology of karst areas are complex, and it is difficult is difficult to achieve the desired effect with a single model.

2.2.2. Ecological Industry Models in Karst Areas Are Diverse

Ecological industry is dominated by ecological theory, organically combining traditional agricultural experience and modern agricultural technology and planning, organizing and producing new models of modern agricultural development according to local conditions [13]. It is an organic system that includes the ecological environment and living conditions of industry, agriculture, residential areas and so on. Therefore, it spans the primary production sector, the secondary production sector and the service sector, including eco-industry, eco-agriculture and eco-service industries [25]. At present, the main and large-scale ecological industry models in the karst area are as follows: the company is the leading enterprise, the farmers are the industrial workers, the establishment of commodity production bases and the market-oriented comprehensive agricultural development and operation model [20]; an agricultural product base centered on "market + standard + technology + management + environmental protection + insurance + base + company + farmer + government key support", forming a highly intensive, high-quality, efficient and safe production model [26]; a three-dimensional agro-ecological model for planting vegetables, medicinal materials and other economic crops or breeding chickens and ducks in open space in forests; and fruit row spacing by using the temporal and spatial differences and complementary relationships between crops, forests and fruits during growth. Not only can these models improve the utilization rate of land and increase economic benefits, but they can also protect soil, reduce soil erosion and reduce pests and diseases [27] It is a comprehensive utilization model of waste resources based on the development of cow dung, pig dung, chicken dung and other wastes in the breeding industry or the use of biological and microbial process measures [28]; the forest belt model around the city is mainly formed by returning farmland to forests, closing mountains for afforestation and maintaining natural forests [29]. The construction of these poverty alleviation models through ecological agriculture has brought both ecological and economic benefits. To sum up, it can be seen that these ecological industrial models in karst areas are mainly based on agricultural development, and most of them are primary agricultural products, with a single industrial structure.

2.3. Industrial Demonstration

2.3.1. Eco-Industry Application Demonstration

From 2004 to 2006, six standardized demonstration bases for grassland animal husbandry stony desertification prevention and control were established in southwestern Guizhou, southern Guizhou and Guiyang, Guizhou province, and 2000 hm^2 of high-quality artificial forage base was built. Involving 1800 specialized households in grass planting and breeding, the demonstration effect is significant [30]. With the development of the demonstration project, beef cattle breeding demonstration areas have been established in Zhanjie, Liuchang and Anliu Town and Qingzhen City, Guizhou Province, with 952 farm households, 12,000 acres of artificial grassland and 3237 hybrid beef cattle [31][32]. Seven breeding demonstration sites have been established in Qinglong County, Guizhou Province. Each demonstration site has established a sheep breeding base, a high-quality mutton sheep fattening base, Artificial Forage Planting and an improvement base to combine demonstration, production and promotion [33]. In Xin'an Town, Pingguo County, Guangxi, a standardized meat rabbit breeding demonstration farm covering an area of 3.6 hm^2 and supporting three meat rabbit deep processing production lines has been established. It is the only demonstration base of meat rabbit breeding and processing in Guangxi [34]. These demonstration bases have promoted the development of ecological aquaculture in the surrounding areas, but the market for these products basically depends on the government or management enterprises. Their retail market is limited, and some products are basically sold domestically.

2.3.2. Eco-Industry Demonstration Benefits Are Remarkable

The demonstration of the three-dimensional ecological agriculture model of forest, fruit, tea, medicine and vegetables promoted the recycling and reuse of materials in the agricultural ecosystem and achieved a unified effect of ecological development, ecological environmental protection and renewable utilization of energy and economic benefits [32]. For example, the Guizhou Taro Stem Horticulture New Technology Development Company grows *Lycoris radiata* on barren hills and wasteland rented by farmers in Maizhi Village and Baiyi Township, Dongfeng Town, Wudang District. Add in the annual net income of CNY 3000 per mu and the wages of reemployed farmers, and the average annual income of farmers will reach more than CNY 12,000. In 2007, the project realized an output value of CNY 500,000, increasing farmers' income by CNY 100,000. Under the leadership of the company, *Lycoris* cultivation is advancing on the road of green development of "chain development and recycling", helping farmers increase their income [35]. Lin demonstrated the application of the principle of three-dimensional agriculture and the Directional Cultivation Technology of corn nutrition group seedling and practiced the three-dimensional planting and breeding mode of "rice, corn, fish, mushroom and vegetable" in a low-yield paddy field in the rock hill area of Northwest Guangxi. Compared with the control (simply planting double cropping rice), the output value increased by 579.5%, the net income increased by 759.2% and the reciprocating utilization of agricultural resources was realized [36]. The economic effect of the model demonstration is remarkable, but the ecological products of most three-dimensional ecological industries are relatively singular and lack industrial innovation according to local conditions.

2.4. Monitoring and Evaluation

2.4.1. Comprehensive Monitoring and Evaluation System of the Rocky Desertification Ecological Environment System

The evaluation of ecosystem stability and sustainability before and after the treatment of eco-environmental vulnerable areas is conducive to ecosystem health management, and points out the direction for the correction of treatment methods and follow-up treatment paths of eco-environmental vulnerable areas. The comprehensive benefit evaluation of rocky desertification includes ecological benefits, economic benefits, and social benefits [37]. The evaluation of ecosystem stability after karst rocky desertification control mainly focuses on the evaluation of cultivated land fertility [38], water quality monitoring [39], soil and water conservation benefits [40], grassland animal husbandry benefits [41], characteristic forest industry benefit monitoring, shrub and grass restoration benefits [42], rocky desertification sensitivity, ecological restoration [43] and carbon sequestration benefits [44] and the comprehensive monitoring and evaluation of ecological benefits [45]. Sustainable benefits focus on the benefits obtained by ecological and social development in stability and protection in development [46]. The construction of various ecological models, research and development technology and application demonstrations have brought huge ecological benefits to karst areas, but the main socio-economic benefits depend on the ecological industrial cycle and sustainable development. Obviously, paying attention to its ecological benefits is often not enough. The socio-economic benefits before and after rocky desertification control are also one of the indicators for the evaluation of rocky desertification control. The ecological environment is the advantage of ecological resources, and high-quality ecological products are the transformation of ecological resources into economic resources, and their good quality corresponds to a wider market [46]. Therefore, the quality evaluation of ecological products is also very important for the evaluation of the benefits of rocky desertification control.

2.4.2. The Quality Evaluation of Ecological Products Has Limitations

Different growing environments have a great impact on the quality of ecological products. As one of the achievements in the governance of ecologically fragile areas, the quality of ecological products directly affects the economic benefits of ecological industries, and indirectly affects the demonstration and promotion of ecological industries. Generally, the quality of ecological agricultural products mainly includes the sensory quality, nutritional quality and flavor quality. Temperature, light, moisture, altitude and environmental pollution are the main factors affecting the quality of ecological products. The soil and water of the fragile karst ecological area have high contents of mineral nutrients such as calcium and magnesium, and the ecological environment pollution after rocky desertification treatment is small. Its good ecological environment is of great significance for improving product quality. Li Baojiang analyzed the content of mineral elements in the fruit of 22 apple varieties. The results showed that the varieties with high calcium and potassium content and low manganese and copper content had good fruit flesh, good storage resistance and good flavor quality. However, zinc content had little effect on fruit flavor, meat quality and storability, and the zinc content of high-quality varieties was relatively low [47]. Glenn used pear as the test material. Through calcium infiltration treatment, it was found that the pectin decomposition of the fruit after calcium treatment was slow during the storage period, which could maintain a high degree of fruit hardness and brittleness, showing strong storability [48]. Different crops have different adaptability to the environment [49], and the research on the change in fruit quality due to the influence of specific environments is not enough. The impact of ecological factors on fruit quality is difficult to quantify and has strong limitations, so it is difficult to establish a systematic ecological product quality evaluation system.

2.5. Product Market

Ecological Product Information Does Not Match Market Information

Under the influence of the Internet, the consumption habits and consumption patterns of the public are constantly changing, and ecological products have both advantages and disadvantages in market circulation. The advantage lies in its ecological value and in being green and organic, which conforms to the requirements of contemporary people for life. Its disadvantage also lies in its ecological value. Behind the ecological resources, there is higher technology, more labor and more precise strategies [50]. The products have higher prices than ordinary products. The scope of the market space for high-priced commodities depends on the purchasing power of consumers. For high-consumption groups, the market space is larger, while for low-consumption groups, the market space is small [51]. With the improvement in living standards, people pay more attention to the quality of products than before while paying attention to food and clothing. Moreover, chemical pesticides are widely used, resulting in the serious pollution of the soil and water in agricultural production. There are various heavy metal or harmful substances pollution problems in the products. Ecological products have gradually become a big trend and have become a necessity of life. Karst areas are mostly mountainous and impoverished areas with poor infrastructure and inconvenient transportation. In addition, most of the ecological products in karst areas are in the early stage of development, with no established brands and insufficient publicity. Therefore, most of the ecological product information does not match the market information, which leads to problems in production and operation in the later stage, and the ecological industry even faces the risk of bankruptcy.

2.6. Value Realization and Promotion

2.6.1. Insufficient Supply Capacity of Ecological Products

With the improvement in living standards and the popularization of the concept of ecological civilization, high-quality ecological products have increasingly become a concentrated reflection of the urgent needs of the people. When the pressure of economic growth on the ecology and the environment continues to increase, human beings use and transform the ecosystem on a large scale, and the over-exploitation, extensive utilization and extravagance and waste of resources that restrict sustainable development are common [52]. As the carrier of ecological products, the extensive exploitation and the inadequate protection of natural resources directly lead to the potential shortage of supply of ecological products and structural regional imbalance, resulting in the increasingly prominent contradiction between supply and demand, influencing people’s pursuit of a better life. First, in the process of industrialization and urbanization, ecological land and the attached ecological resources are directly destroyed and eroded, and industrial emissions pollute the soil and atmosphere. In addition, the ever-increasing human demand for ecological products leads to the over-exploitation of resources, resulting in the degradation of ecological functions of resources, such as excessive deforestation and the mining of mineral products. A series of ecological problems have led to a serious decline in the supply capacity of ecological products. The ecological well-being of human beings has also been continuously reduced, and the supply of ecological products has been inefficient [15]. The fragile ecological environment of the karst area has high requirements for plants. Drought-tolerant and calcium-loving crops are the first choice for karst rocky desertification control. After rocky desertification control, the environmental carrying capacity of the ecosystem is limited, and the supply of ecological products is also limited.

2.6.2. Various Modes of Realizing the Value of Ecological Products

The spatial realization path of the value of ecological products is to take the value of ecological products as the guide; find the location, value and circulation elements in the space [53]; carry out reasonable planning, design, development and utilization of ecological space by scientific means; and improve the production efficiency and supply efficiency of ecological products. The trading of ecological products should follow the market rules and form a reasonable trading mechanism. Ecological products have the characteristics of dispersion, liquidity and regionality. Most of them cannot be directly incorporated into the specific tangible market for exchange, but they must still abide by the principles of openness, fairness and impartiality for trading or compensation. In essence, the market is to regulate the production, distribution, exchange and consumption of ecological products and solve the contradiction between economic development and ecological protection [54][55]. The value realization modes of ecological products include the following [28][56]:

(1) Industrial ecotype: Taking the ecological economic system as the main line, within the carrying capacity of the ecosystem, fully coupling and optimizing the industrial system, natural system and social system in a specific geographical space. Establish a circular economy ecological chain between different industries and enterprises, reduce waste discharge, reduce pollution and damage to the ecological environment and reduce the impact on the ecological environment during the entire life cycle from raw material extraction to product manufacturing, transportation, use and disposal.

(2) Ecological industry type: Promote ecological construction according to the law of industrialization, operate the ecosystem as a special capital-ecological capital, promote the transformation of ecological factors to production factors and ecological wealth to material wealth, establish a virtuous cycle mechanism between ecological construction and economic development and maintain and increase the value of ecological resources.

(3) Property right transaction type: Build a market-oriented operation mechanism, promote the formation of endogenous incentive power for ecological enterprises, and realize the commercialization and marketization of ecological resource asset products.

(4) Ecological compensation type: Ecological compensation is an institutional arrangement aimed at the protection and sustainable use of ecosystem services, focusing on economic means, regulating the interests of stakeholders and making conditional payments for compensated ecosystem services based on bilateral agreements.

2.6.3. The Development and Improvement of Ecological Product Preservation Technology

Product preservation has become an important link in the process of agricultural production. The losses caused by decay make producers and operators bear huge economic risks. Therefore, storage and transportation preservation has become a hot issue in agricultural technology research today. The ripening effect of ethylene, the respiration of fruit tissues and the growth of bacteria are the main factors affecting fruit quality and causing postharvest rot [57]. At present, the research on fruit preservation technology is mainly carried out for the above reasons. The proven technologies include chemical reagent preservation technology, natural plant extract preservation technology, physical preservation technology and genetic engineering technology. Based on the principles of strong operability, low cost, naturalness and being pollution-free [58], according to the actual conditions of the varieties in the demonstration area, finding suitable fresh-keeping and processing technologies to extend the shelf life of products will help farmers obtain higher economic benefits. In the actual preservation of fruits and vegetables, simply relying on one method to preserve freshness often cannot achieve good results, and a variety of methods are required to ensure the freshness of fruit and vegetable products. Vigorously strengthening the research of physical preservation technology, natural chemical substances, biological preservation technology and comprehensive preservation technology will provide new ways or means to preserve fresh fruits and vegetables. At the same time, it will also reduce the loss and waste of fruits and vegetables and other crops. With the continuous development of science and technology, more and more new materials and technologies have been gradually integrated into the preservation methods. For example, radiation preservation has achieved better results in the preservation of fruits and vegetables.

2.6.4. The Promotion of Ecological Product Deep Processing Technology Is Limited

One of the important ways to enhance the value of fresh fruits is to deep-process ecological products, retain nutritional value and eliminate the limitations of distance, transportation and time. With economic development and people's pursuit of high-quality food, fruit and vegetable processing, like other foods, is moving towards nutrition, high-grade, convenience, leisure, health and being green. High and new food processing technologies such as membrane separation, microencapsulation, supercritical extraction, ultra-high-pressure sterilization, freeze-drying, extrusion and biotechnology are more and more widely used in fruit and vegetable processing, which makes the processed products develop to high quality, high level, high grade and diversification [59]. The products of canned storage technology for the deep processing of fruits that we often see in our life, that is, canned fruits, fruit juice beverage processing technology, fruit sugar technology, dried fruit dehydration technology, vacuum freeze-drying technology, etc., have a good market prospect [60][61], but the process is complex. However, to ensure economic benefits, its market price must be higher.

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