

## *Original Paper*

# Environmental Sustainable Development: Study on the Value Realization Mechanism and Diversified Realization Path of Ecological Products under the Background of "Double Carbon"

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### **Abstract**

*Under the background of carbon neutrality and common prosperity, the importance of carbon sinks is constantly highlighted. Realizing the value of carbon sink ecological products is not only conducive to the realization of the goal of carbon neutrality, but also an effective way to promote the endogenous development of rural areas and promote common prosperity. Broadening the value transformation channel of carbon sink ecological products and realizing the sustainable transformation from "green water and green hills" to "Jinshan and Yinshan" provide a new way to achieve the goal of carbon neutrality and common prosperity. Based on the theoretical analysis of the traditional connotation, formation mechanism and value of carbon sink ecological products, this paper summarizes the main ways and existing problems of realizing carbon sink ecological value in China, systematically analyzes the two-way promotion relationship between the double carbon target and the realization of carbon sink ecological product value, and emphasizes the important role of carbon sink ecological value realization and participation in carbon market transactions in carbon emission reduction. It also summarizes the experience of international typical cases. Finally, suggestions and reflections were put forward for redistributing the supply of ecological products based on carbon sinks, improving the basic system for calculating the value of ecological products, strengthening the government's guiding role, improving the ecological rights trading market, and innovating financial models, providing reference for optimizing*

*the innovative mechanism and path for realizing the value of ecological products in China under the "dual carbon" goal.*

**Keywords**

*Carbon sink, Ecological products, value, Carbon peaking, Carbon neutrality, Policy recommendations*

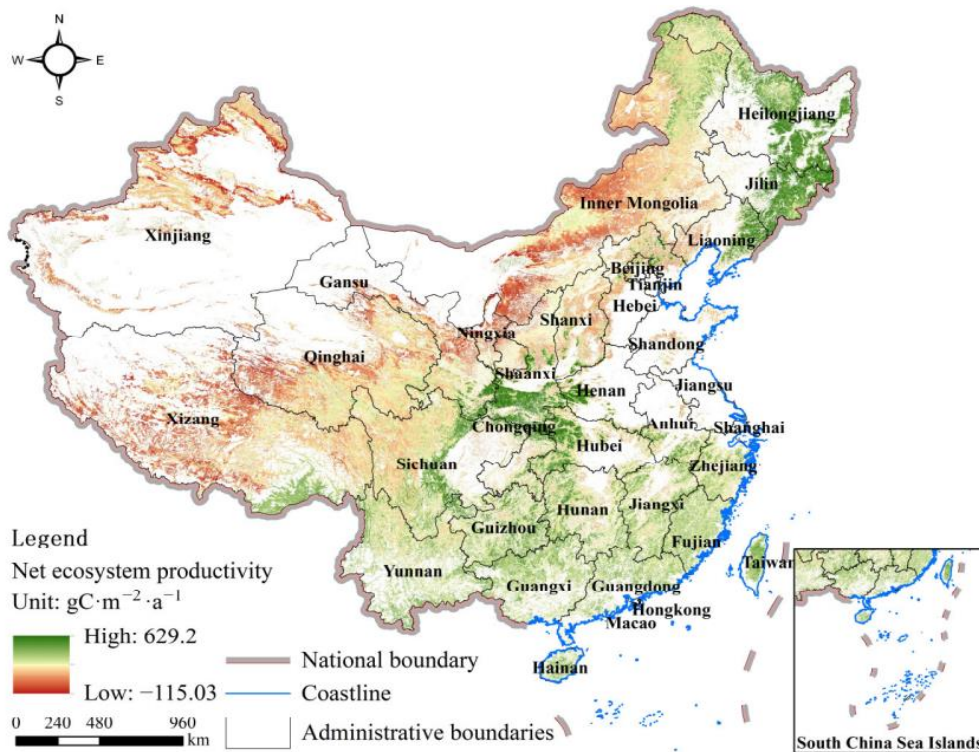
**1. Introduction**

Driven by the dual goals of carbon peak, carbon neutralization and common prosperity, it is of great theoretical and practical significance to expand and improve the value realization mechanism of ecological products. The realization of the value of ecological products and the goal of "double carbon" is the endogenous requirement of high-quality economic development and the only way to comprehensively promote the construction of ecological civilization. The coordination of the two needs to explore the mechanism innovation of ecological product value realization and its path optimization under carbon constraints, so as to practice the theoretical connotation of "green mountains are golden mountains and silver mountains" and solve the dilemma of regional carbon emission reduction and economic development. In the process of practicing the value of carbon sequestration ecological products, government departments and researchers are facing many difficulties. This requires us to analyze the traditional connotation and formation mechanism of ecological products and their value in theory, summarize the main ways and existing problems of realizing the value of ecological products in China, and systematically analyze the two-way promoting relationship between the "dual carbon" goal and the realization of ecological product value, The important role of realizing the value of carbon sequestration products in ecological products and participating in carbon market transactions in reducing carbon emissions (Hametner, 2022; Ilic., 2019; Cf, 2015; Shen, Liu, Xiong, & Li., 2022; Wang, Zhang, Qian, & Wang, 2023).

Ecological products are an innovative concept proposed in the process of ecological civilization construction in China. In a narrow sense, ecological products refer to natural resource elements with ecosystem functions that can provide services such as supply, regulation, culture, and support to humans; In a broad sense, ecological products are products generated by ecosystems that can be reasonably, orderly, and sustainably developed and utilized by humans, including both natural resource elements and products produced through industrial processing of natural resources.

According to the degree of public welfare and the mode of supply and consumption, ecological products can currently be divided into three categories: first, public ecological products, mainly referring to products with unclear property rights and unclear production, consumption, and benefit relationships. The second is operational ecological products, which mainly refer to products with clear property rights and can be directly traded in the market. The third is quasi public ecological products, mainly referring to products with public characteristics that can create demand and carry out transactions through government control. The "Notice of the State Council on Issuing the Action Plan for Carbon Peak before 2030" issued on October 24, 2021, deploys the action to consolidate and enhance carbon sink

capacity, clearly requires the establishment and improvement of ecological protection compensation mechanisms that can reflect the value of carbon sinks, and studies and formulates relevant rules for carbon sink projects to participate in national carbon emission trading. Carbon peaking and carbon neutrality are not simply technical emission reduction issues. They should be included in the overall layout of ecological civilization construction, breaking away from the simplistic approach of binary opposition, and emphasizing the balance between economic and social development goals, especially common prosperity, reflecting the unity of development, sharing, and sustainability. The value realization paths of different types of ecological products vary. Carbon sequestration, as a natural based solution, is considered a more economical and safe climate action, playing an irreplaceable role in the process of carbon neutrality. Against the backdrop of achieving peak carbon emissions and increasing carbon neutrality as a major national strategy, the research on the value realization of ecological products with carbon sinks as a specific research object has significant theoretical and practical significance. To fill the research gap in this field, this article conducted a large number of policy documents and research articles to collect, organize, and analyze. Based on the analysis of carbon sequestration as an important ecosystem service function, the concept of carbon sequestration ecological products is proposed, its basic connotation and classification standards are elaborated, and the main methods for total solid volume accounting and value evaluation are explained. Combined with typical cases, the multiple paths for realizing the value of carbon sequestration ecological products are revealed, And explore corresponding policy guarantees, in order to provide theoretical basis and decision-making reference for deepening scientific understanding of ecological products, promoting carbon peak and carbon neutrality goals, and achieving common prosperity in synergy (Yang, Min, Yang, & Yan, 2022; Fu, Liu, & Meadows, 2023; Ding, 2022; Li & Zhang, 2021; Wang, Xu, & Kong, 2022; Gao & Ouyang, 2022; Lin, Jiang, Li, & Fu, 2022) (Figure 1).



**Figure 1. Spatial Distribution of Cumulative NEP of CES (Lin, Jiang, Li, & Fu, 2022)**

## 2. Research Methods

### 2.1 Literature Analysis Method

Literature research method refers to a research method that forms a new understanding of the existing literature research on the basis of sorting out and collecting the relevant literature in the research field, which is helpful to comprehensively and systematically understand the research direction and progress of the field, to form a preliminary understanding of the research field, and to find out the shortcomings and limitations of the existing research, so as to lay a foundation for the research. According to the existing literature research results, on the one hand, we can form a preliminary understanding of the basic concept and value connotation of Pohui ecological products, the path of value realization, and the existing research perspectives, on the other hand, we can form the main research viewpoints of this paper by summarizing and combing the research ideas and perspectives of predecessors.

### 2.2 Case Analysis Method

According to the analysis purpose of the study, the representative event is selected as the research object, and all kinds of data related to the research object are collected comprehensively and summarized systematically. On this basis, further comprehensive analysis is carried out, and the research conclusions are used as the basis for more extensive research. On the basis of previous literature research and network data collection, this study selected three typical cases for analysis.

### 3. Literature Review

#### 3.1 The Connotation and Extension of the Concept of Ecological Products

In 2010, the concept of "ecological products" was elaborated for the first time at the policy level in the National Plan for Main Functional Areas, that is, important substances for ensuring ecological security, ecological regulation and providing a superior environment, including fresh air, clean water and so on. The main functions of ecological products are to absorb carbon dioxide, produce oxygen, preserve water, purify water, prevent wind and fix sand, regulate climate, purify air, reduce noise, absorb dust, protect biodiversity and prevent and resolve natural disasters. It can be seen that ecological products are important products and public services for human survival and development. Ecological products, together with agricultural products and industrial products, have become necessary and consumable products for human life (Feng & Zhang, 2011). In 2012, the Report of the Eighteenth National Congress of the Communist Party of China further proposed to strengthen the service function and quality management of natural systems and further enhance the supply capacity of ecological products. In 2015, the Outline of the 13th Five-Year Plan put forward the requirement of "creating more high-quality ecological products for the people". In 2016, the Outline of the 13th Five-Year Plan for National Ecological Protection further clarified the connotation of ecological products in specific areas such as cities and scenic spots. Generally speaking, ecological products are an important part of sustainable development, in line with the concept of green development, and become the direction and focus of the construction of ecological civilization in China.

Since the implementation plan of the National Ecological Civilization Experimental Zone (Fujian) issued in 2016, China has started the pilot work of realizing the value of ecological products. In 2017, the State Council issued "Several Opinions on Improving the Strategy and System of Main Functional Areas", listing Guizhou, Zhejiang, Jiangxi and Qinghai as the first pilot provinces to carry out the value realization mechanism of ecological products. In 2018, an intergovernmental conference on the economic belt along the Yangtze River Basin was held to actively explore and promote the transformation from "green water and green hills" to "Jinshan and Yinshan", and to propose the selection of counties with suitable conditions to implement pilot projects to realize the value of ecological products. In 2019, the pilot project of realizing the value of ecological products in Lishui, Zhejiang Province will be launched, and special research projects will be carried out to shift the realization of the value of ecological products from government system design to local pilot verification. The concept of ecological products has distinct Chinese characteristics because of the government's advocacy and implementation. In essence, it is similar to the concept of ecosystem services that foreign countries attach importance to. Compared with the developing countries represented by China, the post-industrialized countries encountered the contradictions and conflicts between social economy and ecological environment earlier, and realized the importance of ecological products in regulating the coupling relationship between ecosystem and social development earlier. Since the 1970s, scholars have enriched and improved the scientific connotation of Ecosystems Services from different perspectives. Holder and Ehrlich (1974)

defined the concept of ecosystem services for the first time, that is, to provide services for human survival and development, such as atmospheric composition, soil formation, material cycle, soil and water conservation, etc. Daily (1997) defines the concept of ecosystem services as "ecological patterns, functions or processes that directly or indirectly enhance human well-being, that is, people can obtain the rights and interests they need from the ecological environment". This is also the definition of ecosystem services widely accepted by western scholars. Costanza et al. (1997) defined it as tangible material products such as food and raw materials created for people, as well as intangible services such as water conservation, air purification, climate regulation, aesthetic value and eco-tourism. In the Millennium Ecosystem Assessment, the United Nations pointed out that ecosystem services refer to the benefits that human beings get from natural ecosystems, including tangible products such as food, water, timber and fiber, and regulating services in regulating climate, floods, disease prevention and control. It provides cultural services in recreation, entertainment, aesthetic enjoyment and spiritual pleasure, as well as support services in soil formation, photosynthesis and nutrient cycling. In 2012, the United Nations "IPBES" platform revealed the service environment created by natural ecosystems from a multidisciplinary perspective, and proposed to replace the concept of ecosystem services with "the contribution of natural resources to people". Costanza et al. (2017) reviewed the main concepts of ecosystem services in academia from 1998 to 2016, and expanded the connotation of ecosystem services to ecosystem products and functions contributing to human survival and quality of life based on classification research methods. In 2001, domestic scholars introduced the concept and theory of ecosystem services, and with the comprehensive and in-depth study of theory and practice, they gradually constructed the Chinese academic discourse system in the global context, that is, the study of ecological products. Since 2010, with the introduction of relevant policy documents on ecological products, the knowledge production and use of "ecological products" have been promoted from top to bottom, and in-depth research on the concept connotation, accounting system, system guarantee and value realization of ecological products has been carried out, it can be regarded as an upgraded version of ecosystem services, proposed to gradually replace ecosystem services with ecological products, and enhance China's academic voice in international ecosystem services research. Compared with the concept of ecosystem services, the strategic intention of eco-products is grand, and the connotation and extension are more precise, scientific and normative. It shows strong vitality in theory and has broad application prospects in practice. However, it can not be ignored that there are still shortcomings in the theoretical and technical research of ecological products, and there is no unified understanding of the value evaluation system, value formation mechanism, trading mechanism and circulation mechanism of ecological products. According to the previous research results, the definition of ecological products can be classified into two categories, namely, the general concept and the specific concept. The general concept of ecological products refers to the consumption of intangible material products such as fresh air, clean drinking water and comfortable climate to meet people's needs, which seems not directly related to people's consumption activities and often has public characteristics. In addition to the connotation of

ecological products mentioned above, the specific concept of ecological products also includes reducing the consumption of natural resources through clean production methods, as well as tangible ecological products such as organic products, green products and pollution-free products, which highlights the characteristics of "natural environment friendliness" of ecological products (Zhang, Yu, Li, et al., 2019; Zhang, Wang, Chen, et al., 2009; Zhang, 2019; Zhang, 2007) (Table 1).

**Table 1. The Concept and Action of Ecological Product in Chinese Government Policy Document**

Years	File name	Contents of the file	Significance
2010	National Plan for Main Functional Areas	The environmental services provided by ecological functional areas mainly include: absorbing carbon dioxide, producing oxygen, conserving water, purifying water, resisting wind and fixing sand, regulating weather, purifying air, reducing noise, absorbing flying dust, maintaining biodiversity and preventing and resolving natural disasters	For the first time, the definition of "ecological goods" is clearly proposed at the national level and emphasizes that ecological goods are the material, regulatory and service products provided by ecosystems.
2012	Report of the 18th National Congress of the Communist Party of China	enhance the production capacity of ecological products and provide more high-quality ecological products	It is pointed out that ecological products can not meet the needs of production and life of the majority of people
2015	The 13th Five-Year Plan for National Economic and Social Development	Put forward to bring more and higher quality ecological products to people	Improving the production capacity and quality assurance of ecological products are pointed out
2016	Outline of the 13th Five-Year Plan for National Ecological protection	It is pointed out that the social supply of ecological products should be increased, the categories of ecological products should be enriched, the allocation level of ecological products should be optimized, and the supply capacity of ecological products and services should be improved	The connotation of ecological products is further clarified and the scope is further expanded
2016	Opinions of The General	Study and formulate the market trading	Two main supply modes

	Office of the State Council on improving the ecological compensation mechanism	system of ecological products, improve the price trading mechanism of ecological products, so that producers can benefit from the ecological product market	of ecological products, ecological compensation and market trading, are defined
2017	Report of the 19th National Congress of the Communist Party of China	To provide more high-quality ecological products to meet the people's growing demand for a beautiful ecological environment	The supply target of ecological products at the national level is put forward
2021	Opinions on establishing and improving the value realization mechanism of ecological products	Strive to promote a path to realize the value of sustainable ecological products advocated by local governments, active participation of private enterprises and all sectors of society, free market operation and sustainable ecological products	A benefit-oriented mechanism has been established, in which environmental protection benefits, users pay and vandals pay compensation.
2021	Outline of the 14th Five-Year Plan	Establish a mechanism for realizing the value of ecological products, and carry out trials in the Yangtze River Basin and Sanjiangyuan National Park	The realization of the value of ecological products is an important task for the national economic and social development in the next five years
2022	Report of the 20th CPC National Congress	Improve the mechanism for realizing the value of ecological products and the compensation system for ecological protection	Take ecological products as necessities of life, and promote harmonious coexistence between man and nature through economic development

### 3.2 Circulation and Value Promotion of Ecological Products

Circulation refers to the activities and services generated in the process of transferring products from producers to consumers, including transportation and distribution links. Products are also called commodities after they participate in market circulation. In this process, individuals exchange products with others to satisfy their needs and desires (Armstrong, Harker, Kotler, et al., 2009). Circulation, as a trading element of commodities, is determined by large-scale socialized production. Circulation is



summarized as material flow in the field of market economy, which does not include the circulation of money, capital and services into products, but only represents the material circulation in the field of economics and management, so product circulation represents the spatial displacement of tangible products from producers to consumers. It can be seen that there is a natural kinship between commodity circulation and market economy. In socialized mass production, product circulation is realized through the exchange of products and currencies. From the perspective of geography, the circulation of ecological products is the spatial flow generated by the transmission of property rights of ecological products among market trading subjects. In a narrow sense, the circulation of ecological products refers to the whole process of circulation of ecological products from production, sale, transportation, processing, packaging, storage, distribution to consumers. The broad definition of ecological product circulation is not only the life cycle of a single product, but also a global supply chain system guided by the system concept, which closely combines business flow, logistics, information flow with production, inventory, handling, packaging and other links, and takes green circulation, Internet of Things and digitalization as the theoretical basis and technical support. The circulation of ecological products includes three elements: participants, organizational form and circulation mode. In the process of ecological products entering the market circulation, in addition to the producers themselves, it is usually necessary to realize the transfer of ecological products from the production side to the consumption side through other market players, and the required circulation process is completed by the "circulation middleman". Generally, brokers, wholesalers, cooperatives, leading enterprises and other "circulation intermediaries" assume the responsibility of ecological product circulation. The organizational form of ecological product circulation refers to improving the overall efficiency of product circulation through the professional division of labor of market participants. The circulation of ecological products has different circulation modes due to different participants and different forms of circulation organization, so ecological products can be freely combined through "circulation intermediaries" to produce different circulation schemes. At the same time, different circulation subjects will choose different circulation modes to participate in the circulation process of ecological products from their own interests, that is, the circulation subjects will face a variety of circulation modes, which depends on the willingness of the circulation subjects to choose. In order to clarify the logical main line between different circulation subjects, following the construction paradigm of economic geography, this paper takes farmers as the research object to explore the choice of farmers in the face of different circulation modes of ecological products. Accordingly, the circulation mode of ecological products chosen by farmers can be defined as: based on the rights and interests of farmers, the value of ecological products can be realized through the circulation process of transaction subjects (acquisition, transportation, storage, etc.). In addition, limited by the types of ecological products in the study area, this study only analyzes the circulation mode of ecological material products, and does not involve ecological service products.

The value enhancement of ecological products, namely value appreciation, is a technology and strategy to obtain more surplus value by enhancing the added value and competitiveness of ecological products,

realizing ecological premium, increasing income and reducing costs. The relationship between the circulation of ecological products and value enhancement is mutual coupling and synergy. The process of product circulation is essentially a gradual value-added process. The circulation system of ecological products from production to sales is based on technological innovation such as production, processing, storage and transportation, and on the premise of ensuring the quality of ecological products, providing consumers with high-quality and environmentally friendly products. During this period, circulation provides a platform for value enhancement, and value enhancement provides a guarantee for the stability and efficiency of circulation. The promotion of the value of ecological products runs through every link of the circulation of ecological products. On the one hand, it pays attention to the moderate management and standardized planting of ecological industries in the production process to provide green and healthy ecological products; On the other hand, in the process of circulation of ecological products, we should rationally plan and improve the construction of storage infrastructure to reduce the value loss of ecological products on the basis of ensuring the realization of the value of ecological products through technological innovation and strategic application. When the quality of ecological products remains stable and has been fully and widely circulated, the social popularity and consumer recognition of their products will be improved, thus further enhancing the value of products. At the same time, the circulation of ecological products should also follow some relevant regulations and standards, which can effectively prevent the emergence of problems such as poor product quality, counterfeit and inferior products, not only improve the circulation efficiency of ecological products and the economic benefits of producers, but also ensure the rights and interests of consumers. The circulation of ecological products helps to enhance the overall value of the industrial chain. On the one hand, the promotion of the value of ecological products requires the innovation of technology and strategy, on the other hand, it requires the producers and middlemen to improve the quality and efficiency of the whole chain of production, transportation, marketing, circulation and sales, and the whole process of the latter is realized in circulation. It can be seen that the circulation of ecological products can promote the optimization and upgrading of related industries, and the various services, logistics, sales channels and other links involved in the industrial chain of ecological products can also be organically coordinated and developed to build a more complete, healthy and orderly circulation system of ecological products, thus promoting the overall value of ecological products (Huang, Li, Wei, & Feng, 2022; Gao, Pan, Zhu, et al., 2013; Yu & Yang, 2022; Xiong & Chi, 2015).

### *3.3 Ecological Products and Market-oriented Ecological Compensation Model*

Due to the late start of the practice and theoretical research of market-oriented ecological compensation in China, the existing research results are relatively few. Zhu et al. (2018) understand market-oriented ecological compensation in the most general sense, and believes that market-oriented ecological compensation mainly emphasizes the role of the market in ecological compensation, and uses market means to achieve the purpose of allocating ecological resources and attracting social capital to invest in ecological compensation. Zou and Jiang (2018) believe that market-oriented ecological compensation

includes various elements such as system, subject, law of value, supply-demand relationship and so on. Ren and Liu (2014) believe that market-oriented ecological compensation is a sustainable development mechanism that combines producers and consumers of ecological service products, takes government regulation and supervision as the core, and uses market means to achieve multi-subject participation in ecological environmental protection. Liu (2014) believes that the essence of market-oriented ecological compensation is to realize the right to use transactions and compensation for development rights through the use of diversified market means. In addition to interpreting the connotation of market-oriented ecological compensation at the general level, Jin and Wu (2019) defines its basic connotation based on the practice of market-oriented ecological compensation in China, believing that market-oriented ecological compensation is an ecological compensation mechanism oriented by industrial ecology and ecological industrialization, with the participation of enterprises and other multiple subjects, and its core is to broaden the sources of compensation funds besides the government. Xi (2018) put forward the characteristics of market-oriented ecological compensation in more detail. The so-called market-oriented ecological compensation refers to the process of compensating the ecological environment builders or the damaged by market means, and marketization is its core connotation, that is, to give the equal market subject status to the ecological environment protectors and the beneficiaries of ecological environment protection; Secondly, establish the rules of market access, competition, trading and so on to regulate market behavior. Thirdly, the price of ecological products in ecological compensation should reflect the relationship between supply and demand in the market. Other scholars put the core of market-oriented ecological compensation into property rights transaction, and believe that the key to establishing market-oriented ecological compensation is to build a trading market connecting stakeholders, so that the subject and object of compensation can realize ecological compensation through property rights transaction on the basis of defining the value of ecological products and the market price of ecosystem services. The essence is to make the property rights of ecosystem service resources market-oriented (Xiong, Zhu, Peng, et al., 2016; Xia, 2022; Bouwma et al., 2018; Stevenson, Auld, Allan, Elliott, & Meadowcroft, 2021; Jin & Lu, 2021).

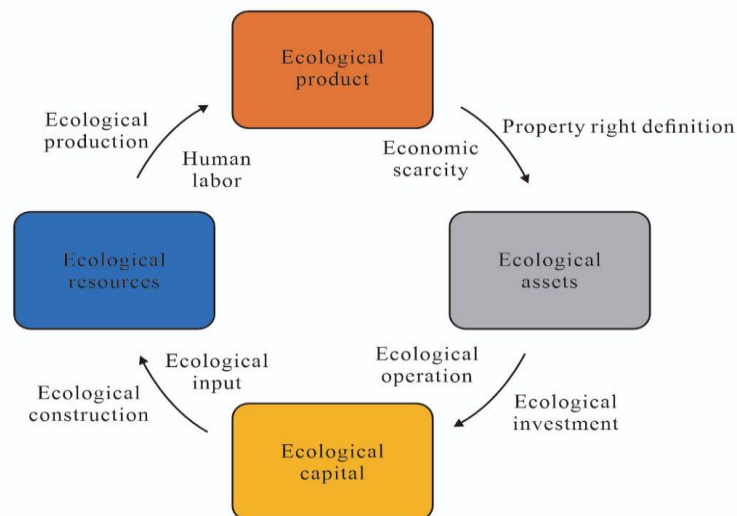
The problem of market-oriented ecological compensation mode is how to operate in practice. With the gradual deepening of the theoretical research on ecological compensation, scholars have made a variety of division of market-oriented ecological compensation models, and put forward a variety of market-oriented ecological compensation models, such as complete market-oriented model, quasi-market-oriented model, government-market combination model and so on, for different areas of ecological resources. In the field of agricultural ecological compensation, based on the particularity of both natural and industrial attributes of agricultural development, Wang and Li (2015) proposed a market-oriented compensation model for green agriculture, which directly compensates for the supply services in ecosystem services, and established a market-oriented transaction model through ecological premium. It can avoid the complexity of property rights transaction and the "alienation" of ecological capital in the traditional market-oriented ecological compensation, and form a "complete

market-oriented ecological compensation model"; In view of the particularity of ecological resources in the Yangtze River Basin, Pan and Zhou (2018) analyzed the current situation and existing problems of market-oriented ecological compensation policy in the Yangtze River Basin, and proposed a "quasi-market-oriented model" of horizontal ecological compensation in the Yangtze River Basin, which is guided by the government, dominated by the market and jointly participated by social capital; In view of the characteristics of ecological resources in the Wuma River Basin, Zeng et al. (2018) calculated the value of ecosystem services in the Wuma River Basin through the analysis of stakeholders' willingness to pay for ecological compensation and the development opportunity method, and proposed that the Wuma River Basin should build a "quasi-market-oriented model" of negotiation and negotiation; Based on the characteristics of the main functional areas in China, Gao and Wang (2010) proposed to implement the ecological service transaction combining government and enterprises, and to establish a market-oriented ecological compensation model combining government and market; In view of the air pollution in Beijing-Tianjin-Hebei region, Liu (2015) proposed to establish the ecological purchase mode of air pollution emission rights trading platform and emission rights secondary market, and in view of the particularity of the ecological service benefits of the river basin, she proposed to establish the negotiation mode and the ecological environment certification mode.

The realization form of market-oriented ecological compensation is the concrete manifestation of market-oriented ecological compensation mode in practice. At present, the academic circles believe that market-oriented ecological compensation mainly has the following forms. One is water rights trading. Liu Wei believes that the market-oriented ecological compensation of water resources can be realized through the establishment of water rights purchase forms of government macro-control, river basin democratic consultation, quasi-market-oriented operation and user participation management. The second is emission trading. Yin and He (2020) proposed that the amount of air pollutant emissions could be purchased through the market trading platform, the total amount of pollutant emissions could be adjusted, and the market-oriented ecological compensation could be realized through the form of emission trading. The third is ecological industry. Li and Li (2014) proposed that we should attach importance to the form of ecological economy based on self-development and realize the purpose of self-compensation through the market. Fourth, ecological purchase also includes green purchase. As a purchaser, the government purchases ecological services or products with green ecological labels from the society, most of which are applicable to natural resources areas or regions with unclear property rights, and are one of the ways to achieve ecological compensation by using market mechanism. Fifth, carbon sink trading. Miao (2017) believes that carbon sequestration trading system is an important form of market-oriented ecological compensation based on the willingness of society to pay for the role of forests in mitigating climate change. Sixth is green finance. Based on the current situation of compensation financing difficulties, Liu et al. (2019) put forward the realization form of green finance. specific measures for green finance, many domestic scholars have carried out in-depth research,

including the introduction of financial means such as ecological lottery, green trust fund, public welfare fund, green bond issuance, PPP model, new third board and GEM listing.

In the process of ecological compensation, financial institutions and social capital should be attracted to participate in ecological compensation. Seventh, the green logo. Based on the attributes of ecological products, put forward the green label as a form of market-oriented ecological compensation, that is, to realize market-oriented ecological compensation by paying higher consideration when consumers choose ecological products. Eighth is inter-regional compensation. Pan and Zhou (2018) proposed that regional planning is an effective form to achieve market-oriented ecological compensation, through the scientific development of different planning areas, to mobilize the enthusiasm of social subjects to participate in ecological protection by means of marketization. Ninth is eco-tourism. Eco-tourism has an incentive to protect the ecological environment of tourist destinations. Tourists bring social and economic benefits to local residents in the process of appreciating and enjoying the natural and cultural landscape. At the same time, it compensates for the reproduction of the local ecosystem, which is another effective form of market-oriented ecological compensation. At present, the specific forms in the practice of market-oriented ecological compensation in China are in line with the forms of realization in theoretical research, which mainly include nine forms, including resource development compensation, emission trading and emission reduction compensation, water rights trading and water saving compensation, carbon trading and carbon sink compensation, ecological industry, green label, green procurement, green finance, regional diversification compensation, etc. (Figure 2).



**Figure 2. The Intrinsic Logic of Realizing the Value of Ecological Products**

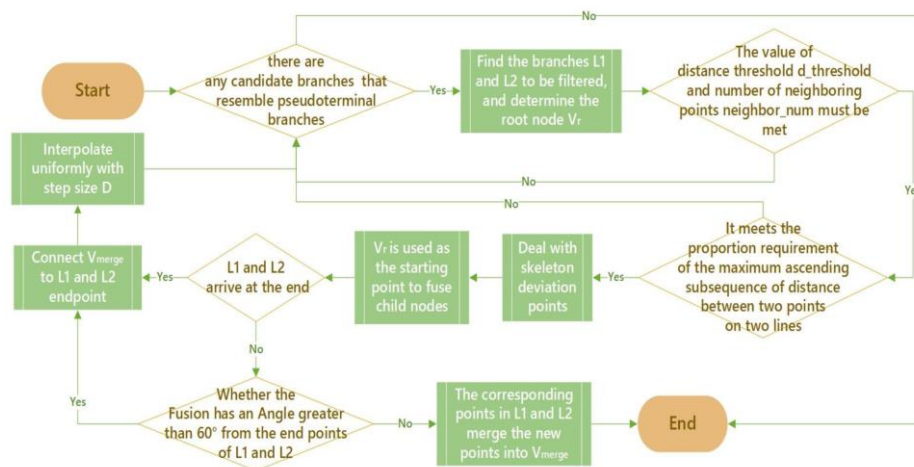
### 3.4 Carbon Sink Ecological Products

Carbon sink refers to a series of mechanisms and activities that absorb and store carbon dioxide from the atmosphere, which can be divided into natural carbon sink and artificial carbon sink. Natural carbon sink is mainly composed of terrestrial ecosystem carbon sink and marine ecosystem carbon sink. Terrestrial

ecosystem carbon sink, also known as green carbon sink, mainly refers to the absorption and storage of carbon dioxide in the atmosphere by afforestation, vegetation restoration, forest management and other measures in terrestrial ecosystems such as forests, wetlands, grasslands, farmlands and karst. As the largest carbon pool in terrestrial ecosystems, forest carbon sinks account for almost half of the terrestrial carbon pool. Among them, the ocean is the largest carbon sink in the earth ecosystem, also known as the blue carbon sink, which mainly includes the fishery carbon sink and the coastal ecosystem carbon sink. The coastal ecosystem carbon sink is mainly mangrove, sea grass bed and salt marsh (Huang, Yao, Wang, Su, & Wang, 2023; Zhou, Shen, Zhong, & Yuan, 2021; Li, Chen, Huang, & Fu, 2021; Zhang, Yu, Li, Jia, Wu, & Liu, 2019; Du, Yan, Feng, Yang, & Yang, 2022). It is worth mentioning that in the karst area, there is a neglected karst carbon sink (Zhang, Yang, Yang, & Yan, 2022). Artificial carbon sink refers to the industrial process of separating carbon dioxide from emission sources or directly utilizing or storing it to achieve carbon dioxide emission reduction, including carbon capture, storage and utilization technology (CCUS), bioenergy carbon capture and storage (BECCS), direct air capture (DAC), etc.. Forestry carbon sinks formed by afforestation, forest management and protection measures can not only directly absorb carbon dioxide in the air for carbon fixation and reduce carbon dioxide content in the atmosphere, but also play a role in protecting biodiversity, preventing soil erosion, purifying air and improving soil fertility (Zhang, Yu, Hao, Wang, & Luo, 2021; Ma, 2019; Li, Bao, & Cui, 2020; Li & Fan, 2022). In addition, the fixed carbon is stored or accumulated in the form of organic matter in the ecosystem to form carbon accumulation, which can provide agricultural and forestry products. These different functions converge to form the value of forestry carbon sequestration. At present, the value assessment of forestry carbon sequestration is based on the calculation of the physical quantity of carbon sequestration and the use of different methods to determine the price of carbon sequestration. In terms of the physical quantity calculation of carbon sinks, the academic community mainly uses the sample plot inventory method, micrometeorology method and model simulation method. The sample plot inventory method is the main measurement method of carbon sinks under the guidance of IPCC guidelines, which takes the biomass or volume as the main source of carbon sinks in forest ecosystems as the accounting object, including the biomass method and the volume method (Liu & Mou., 2020; Sun, 2022; Yan, Wang, Li, & Yu, 2019). The micrometeorological method is a carbon sink calculation method that uses precision instruments to directly measure the dynamic changes of carbon dioxide flux on the basis of the measurement formula, including the eddy correlation method, the eddy covariance method, the relaxation eddy accumulation method and the box method. The model simulation method includes climate-vegetation correlation model, biogeographic model, biogeochemical model, etc. The main idea is to take climate conditions such as temperature, humidity, illumination, precipitation and forest vegetation types as input variables, and to calculate carbon dioxide flux by simulating photosynthesis, respiration and microbial decomposition process of forest ecosystem. At present, there is still a big controversy in the economic value assessment of carbon sinks, and the academic circles have carried out research from different perspectives. Some scholars evaluate from the perspective of cost and benefit,

such as artificial carbon dioxide fixation method, greenhouse effect loss method, afforestation cost method and carbon tax method (Liu, Macpherson, Groves, Martin, Yuan, & Zeng, 2018; Wang, Hu, Yang, Cao, Li, Liang, & Wang, 2014; Wang, Hu, & Cao, 2017; Liu, Dreybrodt, & Wang, 2018; Liu & Dreybrodt, 2015; Yang, Liu, Sun, Yang, & Chen, 2016; Xia et al., 2022). This kind of value evaluation is more for specific carbon sequestration projects. For example, Huang and Chen (2016) considered the cost of land use and wood products, and constructed a forestry carbon sequestration cost model based on the afforestation cost method to analyze the benefits of the carbon sequestration afforestation project in Ruian, Zhejiang; Adger et al. (1995) used the greenhouse effect loss method to assess the value of carbon sequestration services of Mexican forests. Others are evaluated from the market perspective, such as the market value method, which determines the price of carbon sinks through the average value of historical trading data of carbon sinks, and then calculates its value. In addition, because of its simplicity and fairness, carbon tax law has also become a method favored by many scholars. In the value assessment of artificial carbon sinks such as CCUS and DAC, the current research focuses on the matching of carbon source and carbon sink of CCUS (Krklec, Dom ínguez-Villar, & Perica, 2021; Cai, 2009; Xu & Jiang, 1997; Jiang, Jiang, & Lei, 2000; Wu, Zheng, Yang, Chao, & Bin, 2011; Liu, Jiang, Tao, Lang, & Li, 2008). For example, Li (2021) used the high spatial resolution CCUS source-sink matching model to assess the emission reduction potential of China's active coal-fired power plants, quantified the impact of deployment time and transportation distance on the emission reduction potential, and determined the targeted deployment plan at the provincial level. In addition, CCUS technology is often used in the energy sector for carbon capture to achieve emission reduction, and renewable energy as a zero-carbon technology is of great significance for the deep decarbonization of the energy system. However, the development of zero-carbon technologies such as renewable energy will affect the application value of artificial carbon sequestration technology. Based on this, the academia has carried out relevant research on the relative importance of renewable energy and CCUS technology. For example, Grant et al. (2021) used TIAM-Grantham Global Integrated Assessment Model to evaluate the research and found that the cost reduction of renewable energy such as solar photovoltaic and wind power generation will reduce the application value and competitiveness of CCUS. Although artificial carbon sink technology can not replace mitigation measures such as energy efficiency improvement, circular economy and traditional decarbonization, CCUS technology must be used to reduce emissions in cement and other industries. Carbon trading is the main way to realize the value of carbon sinks, and its theoretical basis is that carbon sinks have the characteristics of scarcity, public goods and externalities, so we can use the market mechanism to determine the payment subject to eliminate the externalities to realize the value of carbon sinks. Firstly, the scarcity of carbon sinks is reflected in two aspects, one is the scarcity of carbon sink resources caused by the limited number of forests and carbon sinks, and the other is the limited space of carbon emission rights, which constitutes the value of carbon sinks. In the context of global warming, reducing carbon emissions is an unshirkable responsibility of big countries. However, China is in the stage of rapid economic development, the development of industrial households and urbanization

inevitably brings about the growth of carbon emissions, and carbon emission rights become an increasingly scarce environmental resource. In 2011, China began to carry out the pilot construction of carbon emissions trading, and the total amount control of carbon emissions gradually formed the utility value of carbon sinks. Secondly, as an environmental resource, carbon sink has the attribute of public goods, and its positive externalities can not avoid the emergence of hitchhiking problem, that is, consumers pay less or even no corresponding remuneration to producers while increasing welfare, which leads to various resource elements (Liu, 2023; Zhou, Xiong, Wang, Tang, & Lin, 2022; Ouyang, Wang, & Miao, 1999; Xie, Zhen, Lu, Xiao, & Chen, 2008; Fu et al., 2009; Ouyang et al., 2020; Fan, Lu, Cai, Xu, Wang, Zeng, Xu, & Chen, 2023) (Figure 3).

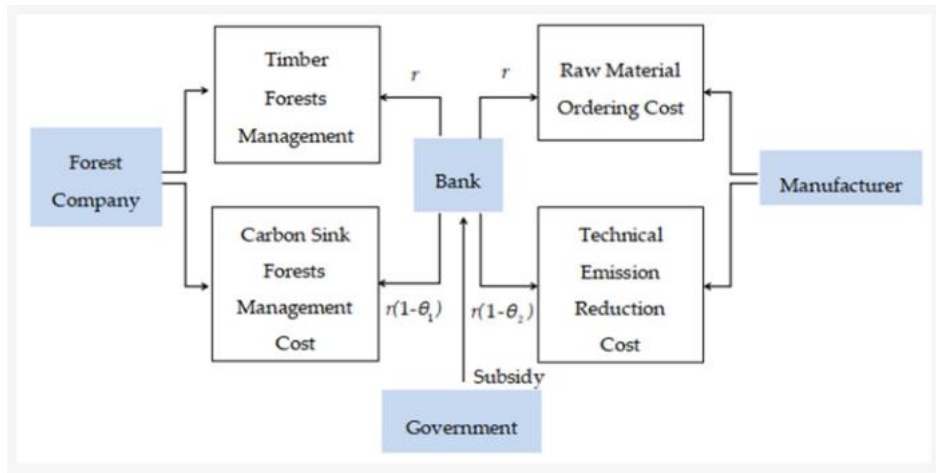


**Figure 3. Algorithm Flow Chart (Based on TLS Point Clouds) (Fan, Lu, Cai, Xu, Wang, Zeng, Xu, & Chen, 2023)**

Therefore, the realization of the value of carbon sinks first needs to clarify property rights. Whether the property right is clear or not will determine the efficiency of resource allocation. It is necessary to rely on the national natural resource property right and use control system, establish a clear property right system of natural resource elements, standardize the right of use, guarantee the right of income, activate the right of transfer, straighten out the right of supervision, and improve the "flexibility" of the realization channel of carbon sink value. Secondly, we should improve the accounting system of carbon sink value, scientifically and accurately evaluate the value of carbon sink, formulate relevant technical standards and methods, and promote the realization of carbon sink value. Thirdly, we should improve the market-oriented allocation of factors, innovate the carbon sequestration trading mode through top-level design, improve the carbon sequestration trading market system, and give full play to the role of the market in the realization of the value of carbon sequestration. For example, Niu (2020) proposed to establish and improve the carbon sequestration trading market composed of the performance market, the inclusive market and the voluntary market, and broaden the channels of carbon sequestration trading.



Finally, we should improve the compensation mechanism of forest ecological benefits, speed up vegetation restoration and improve the production capacity of carbon sinks (Yang, Song, Sun, & Peng, 2020) (Figure 4).



**Figure 4. The Capital Constrained Timber and Carbon Sink Supply Chain (Yang, Song, Sun, & Peng, 2020)**

### 3.5 Research Status of Carbon Sequestration Ecological Product

Li (2023) conducted literature search based on CNKI and Web of Science (WOS) databases, collected a total of 353 articles, and analyzed the current situation, hot spots and trends of carbon sink ecological products research by using bibliometric methods. Since 2002, the number of published articles has shown an explosive trend. The increase is more obvious, with an average annual literature volume of 12, indicating that scholars are paying more and more attention to the circulation and value enhancement of ecological products. CiteSpace is used to analyze the citation emergence relationship of Top25 journals of foreign literature. The red area in the figure indicates the time period when the number of citations of each journal increases sharply. From Figure 2, it can be seen that during the period from 1970 to 2023, the number of citations of ECOSYST SERV increased most significantly; In the past three years, ECOSYSTSERV, INT JENVRES PUB HE, ENVIRON SCI POLICY and GLOBALENVIRON CHANG have been cited more frequently on the topics of circulation and value enhancement of ecological products. This shows that these journals have been popular in the past three years (Figure 5).



Figure 5. Analysis of English Cited Journals (Li, 2023)

The co-occurrence clustering analysis is carried out on the key words, the key words are firstly cleaned, the meaningless words are eliminated, the Synonyms are merged, the minimum occurrence times of each key word are set to be twice, and the key words with the highest occurrence frequency of 200 are screened to form a visual map. Among them, the key words of ecological industry and ecological products appear frequently (Figure 6).

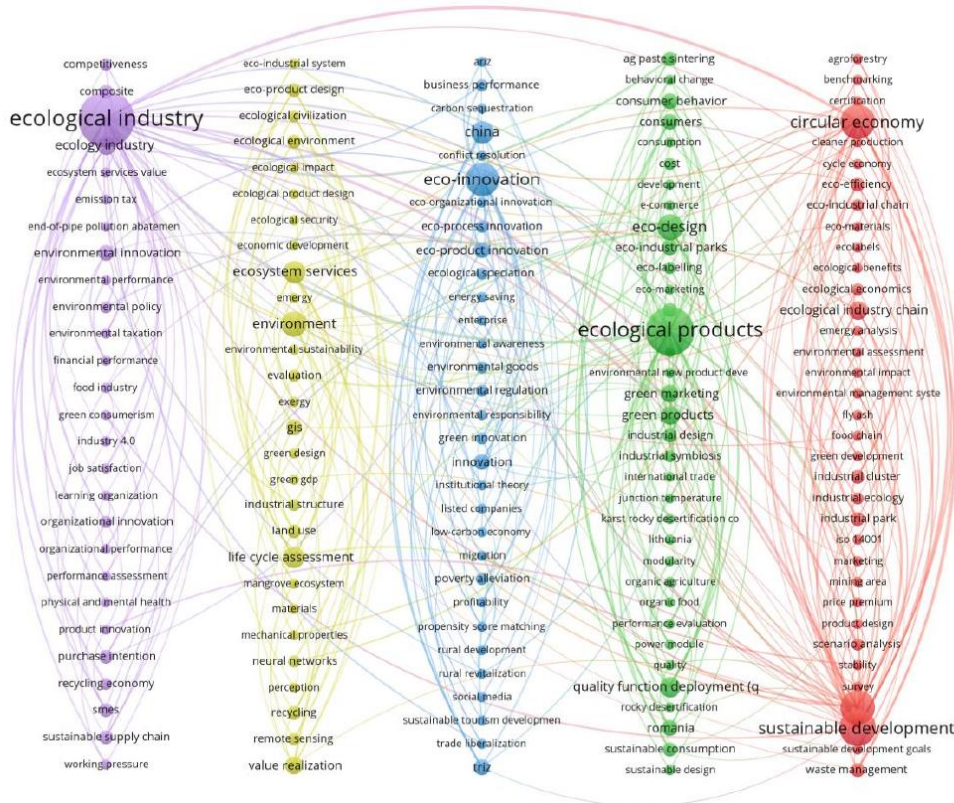


Figure 6. Hotspot Word Frequency Clustering Analysis (Li, 2023)

#### 4. Analysis of Pilot Cases of Ecological Products

How to analyze the challenges faced in realizing the value of carbon sequestration products from a systematic perspective, and explore the realization mode and optimization path of carbon sequestration product value are the issues that this article focuses on. Currently, there are obstacles to realizing the value of ecological products, such as difficulty in quantity, difficulty in collateral, difficulty in trading, and difficulty in monetization. As a type of ecological product, carbon sequestration products face significant obstacles in monitoring, measurement, and basic data acquisition. The consensus on carbon sequestration value accounting is insufficient (Li, 2023; Zhang, Chen, Liang, Wang, & Hao, 2023; Shi, 2021), and the construction of carbon sequestration trading markets is still in the exploratory stage. There are practical problems in promoting the realization of carbon sequestration product value, such as difficulty in quantity, accounting, trading, and monetization. Exploring the value realization mode and optimization path of carbon sequestration products from a systematic perspective can provide reference for solving the practical problems faced by the value realization of carbon sequestration products. The case study method is usually suitable for explaining existing or ongoing phenomena, which is highly compatible with the value realization model of carbon sequestration products discussed in this article. This article extracts the six most relevant elements related to the value realization model of carbon sequestration products from the three aspects of "society economy nature", including conceptual elements, natural elements, institutional elements, subject elements, financial elements, and technical elements. The concept element refers to the guiding ideology and concept for exploring the value realization of carbon sequestration products; Natural factors are the fundamental situation of natural resources that support the realization of carbon sequestration product value; Institutional elements mainly refer to how to regulate the operating environment for realizing the value of carbon sequestration products; The main element is the main body that realizes the value of carbon sequestration products and how to stimulate the internal motivation of main body participation; The funding element mainly refers to how to obtain financial support for realizing the value of carbon sequestration products; Technical elements mainly refer to how to guide the application of science and technology to the value transformation of carbon sequestration products. Overall, promoting the value realization of carbon sequestration products faces three core issues: firstly, the government needs to improve its policy system and guide the value transformation of carbon sequestration products; The second is to establish a mechanism for realizing the value of carbon sequestration products and optimize the allocation of factors; The third is to widely mobilize various forces and enhance the internal motivation of the main body (Li, 2023; Zhang, Chen, Liang, Wang, & Hao, 2023; Shi, 2021; Zhu, You, & Wang, 2021; Zheng, Wu, Peng, & Luo, 2022; Zhao, Xu, Xin, Wang, & Lu, 2022; Yu, Zhang, Li, Yang, Gao, Song, & Wu, 2020; Ye et al., 2022).

##### 4.1 Single Plant Carbon Sink-Guizhou

The development of comprehensive green transformation is of great significance. There has been a lot of research on the mechanism of realizing the value of ecological products both domestically and

internationally. There are many ecological products in Guizhou, and multiple explorations have also been conducted within the province to realize the value of ecological products.

#### 4.1.1 Mechanism for Realizing the Value of Individual Carbon Sink Ecological Products

According to calculations, a tree with a diameter of about 5 centimeters at breast height has an annual carbon sink of about 10 kilograms, which can absorb 10 kilograms of carbon dioxide. The implementation mechanism of the Guizhou Province Single Plant Carbon Sink Precision Poverty Alleviation Project is to number and take photos of trees and bamboo planted by registered poverty-stricken households with a DBH of over 5 centimeters or a tree age of over 3 years, and upload them together with basic information of the poverty-stricken households to the Guizhou Province Single Plant Carbon Sink Precision Poverty Alleviation Big Data Platform. A database containing trees, carbon sink values, and basic information of the poverty-stricken households is established, calculated at a price of 3 yuan per tree's annual carbon sink, Social individuals, enterprises, institutions and social groups are encouraged to purchase carbon through mobile APP or WeChat official account, and the carbon purchase funds will be directly and fully entered into the personal bank accounts of poor households. Poor households do not need to make any investment and have no additional burden. They only need to manage and protect the trees to increase their income.

At the same time, the single plant carbon sequestration project conforms to the global trend of green and low-carbon development. Through the Guizhou Province single plant carbon sequestration precision poverty alleviation service platform, it promotes the concept of addressing climate change to the whole society, advocates green and low-carbon production and lifestyle, and provides a platform for individuals, enterprises, institutions, and social groups to practice green and low-carbon production and lifestyle (Figure 7).

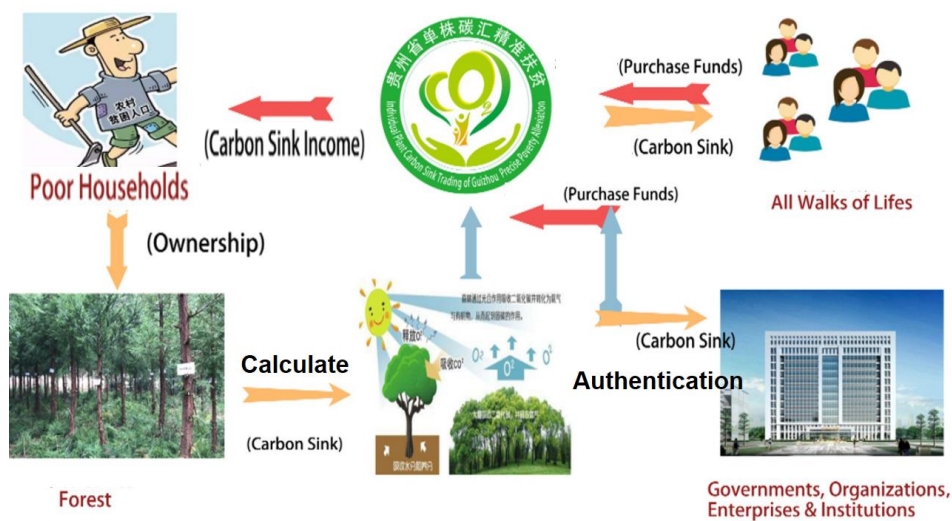


Figure 7. Single Plant Carbon Sink Trading Mode

#### 4.1.2 The Significance of Implementing Single Plant Carbon Sequestration

In terms of economic income increase, single plant carbon sequestration projects have increased the income of impoverished households, transforming the ecological value of their forests into economic value, helping them achieve income increase, and proving to the people with actual income that green mountains and clear waters can be transformed into golden mountains and silver mountains, deepening the concept that green mountains and clear waters are golden mountains and silver mountains

Enters people's hearts. In terms of ecological protection, the people's awareness and initiative to plant trees, protect trees, and care for the environment are constantly enhanced through income growth incentives, which is conducive to continuously expanding forest area, increasing forest stock, improving the natural ecological environment, and promoting the construction of a beautiful China.

At the same time, the implementation of the project is beneficial for the public to cultivate green and low-carbon concepts, raise awareness of ecological environment protection, actively participate in ecological protection, and make the people rich in building a colorful new future of Guizhou with ecological beauty. The project has sustained benefits, with a 6-year validity period for each tree development, and the carbon emissions of impoverished households

The exchange volume can be sold every year, and the increase in income is sustainable, which can effectively consolidate the achievements of poverty alleviation for impoverished households and assist in rural revitalization. Nowadays, China has become an important participant, contributor, and leader in global ecological civilization construction. In 2020, the Chinese government solemnly committed to the "3060" independent contribution goal of addressing climate change to the world. The implementation of single plant carbon sequestration projects can help stabilize and enhance the carbon sequestration capacity of forestry in our province, laying the foundation for achieving carbon neutrality goals in Guizhou Province in the future.

#### 4.1.3 The Mechanism for Realizing the Value of Ecological Products by Single Plant Carbon Sink

As of the end of 2020, the province has completed the development of single carbon sequestration projects for 11207 impoverished households in 682 villages and 33 counties, with 4.462 million single carbon sequestration trees developed and an annual sales carbon sequestration amount of 13.386 million yuan. The project has played a special role in the poverty alleviation campaign in the province, effectively solving the income increase problems of special groups such as more forest land, less arable land, insufficient labor force, and limited income channels. It has been fully recognized by provincial leaders, actively supported by the masses, and widely concerned by society. The State Council and the National Development and Reform Commission have included the precise poverty alleviation mechanism of single plant carbon sequestration in Guizhou Province in the "National Ecological Civilization Pilot Zone Reform Measures and Experience Promotion List". But we also noticed that the project has problems such as low development efficiency, incomplete ecological products, insufficient social participation, and incomplete long-term mechanisms. Therefore, in the next step, we will focus on reforming the project from expanding the scope of project implementation, improving project

development efficiency, establishing and improving a long-term carbon sales mechanism, and assisting in establishing a poverty prevention and assistance mechanism. This will enable the Guizhou Province single plant carbon sink project to continue to play a positive role in assisting rural revitalization, consolidating poverty alleviation achievements, promoting the concept of addressing climate change, and cultivating a green and low-carbon lifestyle. How to make individual carbon sinks a long-term and broader ecological product value realization mechanism? One is to expand the scope of project participants. Before 2020, the participants of the project were registered poverty-stricken households. At present, we are considering gradually expanding the scope of participation with the aim of assisting rural revitalization and enhancing forestry carbon sequestration. The second is to further expand the range of exploitable tree species. Expand the project development tree species from current trees and bamboo forests to all eligible tree species with carbon sequestration properties and ecological product value in the province. Thirdly, we will strengthen mobilization for public welfare carbon purchases. Increase publicity and mobilization for the public, and attract them to actively purchase individual carbon sinks in various forms and rich content. The fourth is to strengthen the constraint of responsible carbon purchasing. Guided by the peak of carbon emissions before 2030 and carbon neutrality before 2060, explore the introduction of carbon emission impact assessment, allowing carbon emitting enterprises to achieve carbon reduction by purchasing forestry carbon sinks. Fifth, improve economic support policies. Implement duty-free policies for the public, organizations, and enterprises to purchase carbon sinks for public welfare purposes. Support and encourage financial institutions to carry out green credit, green bonds, green venture capital, green securities, green insurance, etc. in combination with project innovation, promote carbon finance products and services, and build a green financial service system composed of inclusive finance, green bonds, ecological funds, and ecological insurance. Taking the value realization mechanism of individual carbon sequestration ecological products as an example, in Guizhou, how should we enrich the types of ecological products, enable them to exert greater value, and assist in rural revitalization? Firstly, it is necessary to conduct an inventory of the ecological products in the province, comprehensively investigate the natural resources such as land, minerals, forests, wetlands, grasslands, rivers, lakes, groundwater, etc. that can be converted into ecological products in the province, form a large database of ecological products in the province, conduct physical quantity accounting of ecological product supply, service quantity, or alternative value, and explore the value accounting of physical quantity. Secondly, we need to develop ecological products in multiple ways and in depth, actively guide impoverished areas with important ecological functions and abundant ecological resources, adjust measures to local conditions, strengthen the understory economy, ecological health and other ecological industries, diversify and diversify the ecological service products of ecological agricultural products, ethnic culture, and ecological tourism, deeply tap into the value of various ecological products in our province's "big ecology", and truly turn green mountains and waters into golden mountains and silver mountains. At the same time, establish a price formation mechanism, cost monitoring system, and price adjustment mechanism for ecological products, accelerate the promotion of

forestry carbon sequestration, water rights, and energy rights, and manifest ecological functions with huge market value such as carbon emissions, pollution discharge rights, water rights, and forest rights (Wang, Zhu, Wen, Xie, & Liu, 2020; Sun & Peng, 2021; Qiu, Luo, Zhu, Yang, & Wang, 2022; Lu, 2022; Gao, Wang, Yang, Sun, Liu, & Feng, 2022; Li & Chen, 2021).

#### 4.2. Forestry Carbon Sink Trading in Sanming City-FuJian

Sanming City, located between Wuyi Mountains and Daiyun Mountains, is rich in forest resources, with a forest coverage rate of 78.73%. It is an important forest product processing base in Fujian Province and a national pilot reform zone for collective forest areas. The total carbon sequestration of forests is 340 million tons, with an annual increase of about 11.7 million tons. In recent years, Sanming City has achieved good results in promoting the value realization of carbon sequestration products by leveraging its advantages in forest resources. The specific approach includes the following four aspects

##### 4.2.1 Clarify Forest Property Rights

Introduce the "forest ticket" system to promote the large-scale operation of forestry. Sanming City mainly has collective forest rights. From 2003 to 2005, Sanming City carried out forest property rights system reform, clarifying forest property rights, and using modern technology to build an information platform for managing forest rights. In addition, Sanming City is exploring the reform of the "three rights separation" of forest rights, separating the ownership, contracting rights, and management rights of forestry. The ownership belongs to the collective, and local families have the contracting rights, while the management rights can be transferred. After the forest rights reform, in order to solve the problems of local forest farmers lacking technology and funds, and relatively backward management concepts, the Sanming Forestry Bureau issued the "Sanming Forest Ticket Management Measures (Trial)" to promote large-scale forestry management. Through the innovation of the "forest ticket" system, it drives state-owned forest enterprises to cooperate with village collectives and farmers, and improves the local forestry management level.

##### 4.2.2 Carbon Sink Methodology

Innovate forestry carbon sequestration methodology and promote the forestry "carbon ticket" system. In order to prevent forestry carbon sequestration from being oversold, in March 2021, Sanming City launched a forestry "carbon ticket" system, providing "identity cards" for regional forestry carbon sequestration transactions and regulating the realization of the value of forestry carbon sequestration ecological products. In May 2021, the Development and Reform Commission of Sanming City and other departments jointly issued the "Sanming City Forestry Carbon Ticket Management Measures (Trial)", further clarifying the management system of "carbon tickets". According to the traditional forestry carbon sequestration methodology, natural forests, ecological public welfare forests, etc. cannot develop forestry carbon sequestration projects. However, the forestry "carbon bill" in Sanming City is much broader, and as long as the ownership of forest land and trees is clear, they can apply for a "carbon bill". In terms of measurement, the increase in tree growth can be converted into net carbon sequestration, which can more clearly reflect the carbon sequestration function of forests.

#### 4.2.3 Diversified Development

Explore diversified ways to realize the value of forestry carbon sequestration. Since 2010, Sanming City has taken the lead in carrying out pilot forestry carbon sequestration trading in the province. Currently, 12 forestry carbon sequestration trading projects are planned, with a transaction amount of 19.12 million yuan. In addition to the "forest ticket", the pilot forestry carbon sequestration trading project in Sanming City also includes international certified carbon reduction (VCS) and Fujian forestry carbon sequestration (FFCER) trading, forming a diversified forestry carbon sequestration value conversion method.

#### 4.2.4 Green Finance

Develop green finance to assist in the value transformation of forestry carbon sequestration products. In 2015, the Sanming Municipal Government issued the "Implementation Plan for the Construction of the Green Finance System in Sanming City", taking forestry financial innovation as the starting point, and making comprehensive efforts in forestry finance, green credit, green enterprise listing and refinancing, green bonds, green insurance, and mobilizing social capital to participate in the construction of the ecological civilization pilot zone. A green finance work leadership group led by the mayor of Sanming City was established, Promote the development of the green financial system. In addition, Sanming City innovates financial products such as forestry mortgage loans, carbon sink loans, and forestry carbon sink pledges to promote asset circulation and improve market efficiency. At present, the balance of forest rights loans in Sanming City accounts for more than half of Fujian Province.(Figure 8)



**Figure 8. Sanming City Forestry Carbon Coupon**

Through the practice of "forest ticket" and "carbon ticket", the development of the local carbon sink trading market has been promoted. At present, there are over 3000 forestry business entities in Sanming City, including state-owned enterprises, collectively owned enterprises, family forest farms, joint-stock forest farms, forestry professional cooperatives, social organizations, and other diverse entities. Since



2018, the transaction amount of forestry carbon sequestration products has reached 25.34 million yuan, benefiting 14400 households and approximately 60600 villagers. The annual collective income of the village can increase by more than 50000 yuan, and the transaction volume and amount of forestry carbon sequestration products are ranked first in Fujian Province. Although the exploration of forestry carbon sequestration in Sanming City has achieved good results, there is still a lack of motivation from both supply and demand sides in the market, and there is a lack of national unified standards in carbon sequestration monitoring, measurement, and other methodologies. In the future, it is still necessary to continue to promote more scenarios and large-scale conversion of carbon sequestration product prices.

#### 4.3 Ocean Carbon Sequestration Pilot-FuJian

At the Ocean (Fisheries) Carbon Sequestration Summit Forum held in Fuzhou in June 2023, the People's Government of Lianjiang County, Fuzhou City successfully issued the first blue carbon ticket to Fujian Yida Food Co., Ltd. in China. The carbon tickets for this pilot project are registered by the Municipal and County Marine and Fisheries Bureaus, monitored, evaluated, and certified by third-party institutions. The Lianjiang County Public Resource Trading Service Center provides registration, cancellation, circulation, and trading services. The blue carbon bill issued this time involves about 172 hectares of blue sea area in Lianjiang, which is equivalent to approximately 27000 tons of carbon reduction. Based on the market reference price of 20 yuan per ton, the carbon trading value can be nearly 550000 yuan. The carbon sink amount in the blue carbon bill is based on the marine industry standard of the People's Republic of China, the "Economic Value Accounting Measures for Marine Carbon Sinks". It is a certificate issued by a third-party organization for monitoring, evaluating, certifying, filing with the Ocean and Fisheries Bureau, and registering with the marine carbon sink trading department, which has the right to receive profits. It grants the rights to pledge, redeem, and offset transactions (Figure 9).



Figure 9. Lianjiang Ocean Carbon Coupon

The "Marine Carbon Sink Accounting Method" approved and released by the Ministry of Natural Resources of China has been officially implemented since January 1, 2023, filling the gap in industry standards for accounting methods in this field. This standard defines marine carbon sinks as the process, activity, and mechanism by which mangroves, salt marshes, seagrass beds, phytoplankton, large algae, shellfish, etc. absorb and store atmospheric carbon dioxide from the air or seawater. Research shows that expanding seaweed farming reduces approximately 2.6 billion tons of carbon dioxide equivalent annually.

## 5. Discussion

From the above cases, it can be concluded that the different product attributes of the value of carbon sink ecological products put forward that the realization of value is multifaceted, which can not be decided unilaterally by farmers, the government and the market, and the compound path is needed, that is, the market path, the cooperation path and the government path are "compounded". In the compound path, it is emphasized that the government should first clarify its leading role, intervene in the realization of the value of carbon sink ecological products with different attributes to varying degrees, provide responsive institutional safeguards and policy support, and create a good social atmosphere. In other words, the compound path is the response to the value realization path of the three carbon sink ecological products, if only one of the paths is adopted, the value transformation of the carbon sink ecological products can not be realized to the maximum extent. Therefore, in the value realization of carbon sequestration ecological products, the government should first accurately identify the ecological products with different types of attributes covered by the value realization of carbon sequestration, select appropriate value realization activities for the value realization of carbon sequestration with different product attributes, and reasonably switch the window of policy tools. In the areas where the government should give full play to the role of administrative intervention, we should use policy support and system to ensure the realization of the leading value; In those areas where market resource allocation and social capital should play a role, we should fully respect market rules and the logic of social operation, promote the rational, smooth and orderly flow and market-oriented allocation of technology, talent, capital, data and other factors, improve the operation mechanism of factor market, fully reflect the value of factors, and realize the high-level transformation of the value of carbon sink ecological products.

### 5.1 Market Path

The market path mainly aims at the carbon sink ecological products with private product attributes, such as agricultural products and forest products, which are manifested in market allocation and market transactions, and realize value through direct transactions. For example, bamboo shoots and bamboo materials in Anji County can generally transform the value of ecological products into commodity value through direct market transactions to develop ecological agriculture, or on this basis, extend the industrial chain, continuously enhance the added value of products through processing and deep processing, promote the development of bamboo processing and manufacturing industry, develop

ecological industry, and at the same time. Realize ecological industrialization management. Therefore, the government should make corresponding organizational management and policy arrangements, and reduce the intensity of administrative intervention as much as possible in the field of market economy, so as to promote the market to play the role of resource allocation and realize product value-added in accordance with market rules.

### *5.2 Cooperation Path*

The cooperative path of government and market is mainly aimed at carbon sink ecological products with quasi-public goods attributes, such as bamboo forest carbon sink in Anji County. As a kind of rights and interests of climate resources, such products can generally realize their value by levying taxes and fees, building an ecological resources rights and interests trading market for property rights trading, etc., which is manifested in the realization of value through government policy support, cultivation of production and trading subjects, construction of ecological resources indicators and property rights trading market. With the entry into force of the Paris Agreement, the importance of carbon emission rights as a new type of development rights has been highlighted, and China, as the largest emitter, is facing huge pressure to reduce emissions. In order to achieve the goal of carbon peak and carbon neutrality, China started the pilot construction of carbon emissions trading in 2011, and officially launched the national carbon emissions trading market in 2021 to promote greenhouse gas emission reduction through government control of carbon quotas. As a supplementary mechanism of the carbon market, the national certified voluntary emission reduction (CCER) provides a more economical way for emission control enterprises to fulfill their obligations. As one of the project types of CCER, carbon sink shows the characteristics of scarcity and positive externality under the effect of carbon market. Therefore, under the control of the government, the process of creating a carbon market by restricting carbon emission quotas actually creates a demand for carbon sequestration trading, thus cultivating a virtual carbon sequestration rights and interests trading market, and the value of carbon sequestration with quasi-public goods attributes is naturally realized by guiding and encouraging the supply and demand sides of carbon sequestration to conduct market transactions. In Anji practice, bamboo forest carbon sinks are generated through the management of bamboo forests, although bamboo forests have clear collective forest rights, but as a climate resource property rights, the ownership, use rights and income rights of bamboo forest carbon sinks need to be redefined, and the platform of "two mountain banks" should be built under the cooperative path between the government and the market. Establish a carbon sink property rights trading market to collect, store and trade bamboo forest carbon sinks on a large scale, so as to realize the transformation of bamboo forest carbon sink resources into assets and capital.

### *5.3 Government Path*

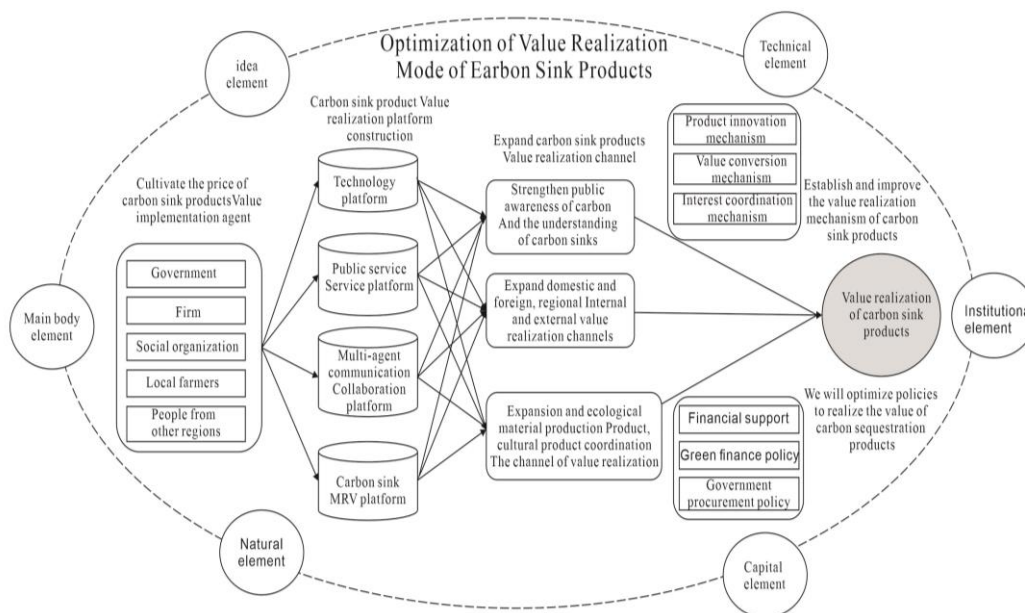
The government path is mainly aimed at carbon sink ecological products with pure public goods attributes, such as climate regulation, water conservation, soil conservation, etc. Its ecological value is difficult to be transformed by market-oriented mechanism, especially based on ecological public welfare forests, so it needs to rely more on direct government path, which is manifested in government policy

support and financial transfer. Implement ecological compensation, ecological engineering and other ways to achieve value. According to the principle of "who benefits, who compensates, who protects, who is compensated", the government should take the lead, provide space guarantee and material basis for value realization through rational planning of land space and use control, and consolidate the ecological basis through strict implementation of ecological restoration and protection policies, so as to create conditions for subsequent rational development, utilization and value realization. In the practice of Anji, in view of the pure public carbon sink ecological products in the ecological public welfare forest, more financial transfer payments are made under the leadership of the government to carry out forest ecological compensation and ecological restoration, so as to further enhance the ecological value of carbon sink.

However, it should be pointed out that the composite path is not a simple superposition of the three paths. In the process of using market path, cooperation path and government path to realize the value of carbon sink ecological products, there may be "failure" of value realization, which is manifested as follows. First, the realization of market value fails. Due to the public goods attribute and externality characteristics of carbon sink ecological products, market failure is inevitable in the process of realizing the value of ecological products through market mechanism, which can be manifested as passive participation in the realization of the value of ecological products, vague responsibility mechanism and regional imbalance, which may damage social equity while bringing efficiency. Therefore, in the process of realizing the value of carbon sequestration products, carbon sequestration ecological products with public goods attributes may cause market mechanism failure, resulting in products and services difficult to enter the market for transactions or high transaction costs, and their consumers and beneficiaries have no interest motivation to pay for the carbon sequestration products and services they enjoy, so it is difficult to avoid the inefficiency of value realization. Second, the realization of cooperative value fails. In the path of cooperation between the government and the market, the value of carbon sequestration can be realized through the government setting up a platform, market-oriented operation, and the construction of multi-subject participation pattern. However, there are still problems in this mode, such as how to coordinate the interests of multiple subjects to achieve effective cooperation and improve the efficiency of realizing the value of carbon sequestration. For example, in the operation of "Liangshan Bank" in some places, the operation of many projects depends on the support of the government, rather than making full use of the market-oriented mechanism, through the direct allocation of government finance, the "Liangshan Bank" uses funds to circulate and operate, which in fact violates the original intention of its establishment, so how to ensure the government? It is worth considering to play its due role. Third, the realization of government value is out of order. Influenced by factors such as "limited rationality", information asymmetry, ambiguity of public interests, limitations of public decision-making system and obstacles to policy implementation, policy errors may occur, which makes the government unable to efficiently supply public goods. Relying on the authority of the government to regulate and guarantee the realization of value, however, this direct way may lead to inefficient use of funds, the government faces a

huge financial gap, resulting in structural imbalance between supply and demand of products and other government failures, leading to the "tragedy of the Commons".

Therefore, in the face of the value failure that may arise from various paths, this paper believes that we should emphasize the government's responsibility in the value realization of carbon sink ecological products, play the role of "meta-governance" of the government, comprehensively use the three value realization paths in the process of realizing the value of various carbon sink ecological products, and realize the coordination among various paths. To jointly construct the value realization path of carbon sink ecological products under the compound logic (Li & Chen, 2021; Zhang & Yang, 2021; Chang, 2023) (Figure 10).



**Figure 10. Value Realization Model of Carbon Sequestration Ecological Products**

### 6. Suggestions

The value realization of carbon sequestration products is a complex system and a multi-subject system, involving the government, enterprises, social organizations, community residents and so on, which requires the coordination of organization, system and space. Usually, there are some obstacles in the path of realizing the value of carbon sequestration products (carbon sequestration products have the characteristics of public goods), which requires the initiator of realizing the value of carbon sequestration products to guide the rational allocation of elements. Through the comparative analysis of cases, we can see that the value realization of carbon sequestration products is a multi-factor-driven system. Through the optimization of the six elements of concept, nature, system, subject, capital and technology, we can promote the optimization of the value realization mode of carbon sequestration products.

(1) Cultivate the subject of value realization of carbon sequestration products. At present, the market supply and demand of carbon sequestration products is not strong, and the main body of supply and

demand lacks the motivation to participate. In the future, we should strengthen the concept guidance and promote the expansion of carbon sequestration products in the national carbon trading market in an orderly manner. On the one hand, we should strengthen the environmental education and propaganda of carbon sequestration products under the guidance of the concept of "two mountains", and make the government, enterprises and residents realize the importance and necessity of realizing the value of carbon sequestration products through the correct concept guidance, so as to provide internal power support for the realization of the value of carbon sequestration products. On the other hand, under the constraints of the "double carbon" target, the central and local governments should form regional carbon emission reduction and carbon sink increase constraint indicators, guide market expectations, and promote the expansion of carbon sink products in the national carbon trading market in an orderly manner.

(2) Strengthen the platform construction for realizing the value of carbon sink products. The efficient operation of the value realization of carbon sequestration products can not be separated from government supervision and specialized infrastructure support, and the government should strengthen the construction of relevant platforms. At present, the value realization of carbon sequestration products is still in the exploratory stage, and various platforms needed for the value realization of carbon sequestration products can be built, such as technology platform, public service platform, multi-subject communication and collaboration platform, carbon sequestration MRV platform, etc., to provide more specialized infrastructure support for carbon sequestration trading. The technical platform and MRV platform provide data support for the quantitative assessment of carbon sequestration trading, provide scientific basis for the quantitative assessment of carbon sequestration capacity of different ecosystems such as forests, grasslands and wetlands, and are also conducive to enhancing China's ability to predict and warn climate change. The public service platform and the multi-agent communication and collaboration platform can strengthen the communication and exchange among the government, market players and community residents, which is conducive to promoting the integration and development of the value realization of ecological products and the livelihood of residents, and promoting the innovation of the value realization mode of various carbon sink products.

(3) Broaden the value realization channels of various carbon sink products. The case study shows that the value realization mechanism of carbon sequestration products has the characteristics of diversification and innovation. Due to the insufficient understanding of carbon sequestration by local residents, there are still regional limitations in the value realization channels of carbon sequestration products, and the channels for carbon sequestration products to cooperate with other ecological products to promote value realization are not enough. In view of the obstacles faced by the value realization of carbon sequestration products, first of all, we should strengthen the social understanding of the concept of carbon neutrality and carbon sequestration products, increase the training related to the value realization mode of carbon sequestration products, and gradually broaden the channels of value realization. Secondly, we should break the current regional restrictions on the realization of the value of carbon sequestration products, connect the national carbon sequestration trading market, and actively integrate into the global carbon sequestration trading

market. Thirdly, according to the characteristics of carbon sequestration products, we should expand the value realization channels of carbon sequestration products and other ecological products.

(4) Strengthen the system construction and policy support for realizing the value of carbon sequestration products. From the case analysis, it can be seen that a perfect system is an important guarantee to promote the value realization of carbon sequestration products. Therefore, we should strengthen the relevant policy research on the value realization of carbon sequestration products, and gradually form a scientific policy support system to ensure the value realization of carbon sequestration products. In the future, on the one hand, we should establish and improve the value realization mechanism of carbon sequestration products, including product innovation mechanism, value transformation mechanism, interest coordination mechanism, etc. On the other hand, we should optimize the policy support for the realization of the value of carbon sequestration products, including financial support policy, green financial policy, government procurement policy and other policy support, improve the investment and financing mechanism of carbon sequestration, and ensure that carbon sequestration, which is not included in the market trading system but has substantial contribution to carbon neutralization, is compensated for its due value (Liu, He, & Wang, 2022; Yu, Shao, Wang, & Hao, 2022; Zhuang, Yu, Hao, & Wang, 2021; Gu, 2022; Wang & Wang, 2022).

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