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Research on the path of forest carbon sinks to help rural revitalization under the goal of carbon neutrality

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Abstract: *In the context of the increasingly severe global climate change problem, carbon neutrality has become a common global goal. As an important means of carbon sequestration, forest carbon sinks are of great significance for achieving the goal of carbon neutrality. Sichuan is rich in forest resources, ranking fourth in the country, and has strong carbon sink capabilities. This article takes Sichuan as an example to discuss issues such as forest carbon sinks helping rural revitalization, increasing farmers' income, and improving the rural environment. Through literature analysis and case studies, it explores the path for forest carbon sinks to promote rural economic development and achieve the goal of carbon neutrality.*

Keywords: *carbon neutrality; forest carbon sink; rural revitalization*

1. Introduction

My country's total carbon dioxide emissions rank first in the world. On September 22, 2020, China announced at the 75th United Nations General Assembly that China will strive to peak carbon dioxide emissions before 2030 and strive to achieve the goal of carbon neutrality by 2060. The proposal of the "double carbon" goal is my country's solemn commitment to respond to global climate change after the Copenhagen Conference. It is also a major strategic decision made by the Party Central Committee in response to major changes unseen in a century. The development of forest carbon sinks is not only my country's response to global climate change. It is an important measure to combat climate change and an important means to achieve the “double carbon” goal and promote rural revitalization. The greatest advantage of my country's comprehensive implementation of the rural revitalization strategy lies in ecology, and the greatest potential lies in forestry. The development of rural forestry is an important way to promote stable agricultural development and increase farmers' income, and is an important way to transform green waters and lush mountains into gold and silver mountains (Gu Jianlong et al., 2022) .[1]

Forests are globally recognized as an effective means of ecological carbon sequestration, and forest carbon sequestration is superior to other emission reduction methods. Scientific research shows that for every cubic meter of trees growing, they absorb an average of 1.83 tons of carbon dioxide and release 1.62 tons of oxygen (Feng Zhaokui, 2008). [2]It can be calculated that a tree can absorb 4-18 kilograms of carbon dioxide in about a year. Therefore, developing forest carbon sinks is my country's strategic choice to deal with climate change, and improving forest carbon sink capabilities is a key task to achieve the "double carbon" goal, especially the carbon neutral goal. In January 2023, the National Forestry and Grassland Administration published the "2021 China Forestry and Grass Ecology Comprehensive Monitoring and Evaluation Report" based on the annual comprehensive monitoring results, announcing new caliber forest resource data for each province (region, city). The "Report" shows that Sichuan's forest area is 381 million acres, ranking first in the country, accounting for 8.9% of the country's total; its forest area is 260 million acres, second only to Inner Mongolia Autonomous Region, Yunnan Province and Heilongjiang Province, ranking fourth in the country. The forest stock volume is 1.895 billion cubic meters, ranking fourth in the country and accounting for 9.7% of the national total.The province's forest coverage rate is 35.72%, which is 11.7 percentage points higher than the national forest coverage rate. Therefore, improving Sichuan's forest ecological carbon sink capacity is of great significance for accelerating the realization of carbon neutrality goals, better safeguarding national ecological security, practicing the development concept of "lucid waters and lush mountains are invaluable assets", and fully promoting rural revitalization.

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2. Research methods and cases

2.1. Research methods

This article uses a method that combines literature analysis and case studies, taking Sichuan as an example to explore how forest carbon sinks can help rural revitalization. First, through literature analysis, we understand the research status and development trends of forest carbon sinks in Sichuan Province; secondly, through field surveys, we understand the development status and existing models of forest carbon sinks in Sichuan Province; finally, through case studies and comparative analysis, we explore the forest carbon sink research status and development trends in Sichuan Province. The path and effect of carbon sinks in promoting rural revitalization.

2.2. Case: Sichuan's largest forest carbon sink - Nova Sichuan Southwest Forestry Carbon sink project

In December 2010, the Swiss pharmaceutical company Novartis invested 57 million yuan, and the national and provincial forestry bureaus invested 13 million yuan to launch the Southwest Sichuan Forestry Carbon Sink Project to purchase carbon dioxide emissions in the form of direct funding for afforestation. The project is located in Liangshan Yi Autonomous Prefecture in southwest Sichuan Province, covering 5 counties in the Dadu River Basin of Sichuan Province: Zhaojue, Yuexi, Ganluo, Meigu, and Leibo. The Provincial Dadu River Afforestation Bureau is responsible for the afforestation business. This is the largest project in Sichuan so far. Forest carbon sequestration project. The project estimates that in the 30 years from 2011 to 2041, afforestation will absorb 1.2 million tons of carbon dioxide, which is equivalent to the annual carbon emissions of 40,000 cars. In order to speed up the implementation of the project, the national and provincial forestry departments have granted afforestation subsidies of 200 yuan per mu. From now on, the company will bear 65% of the annual management and protection cost of 10 yuan per mu, and the remaining part will be allocated from carbon trading.

This project has received gold certification from the International Climate, Community and Biodiversity Alliance (CCBA). It not only protects endangered rare animals including giant pandas, but is also of great significance for restoring the ecological value of the upper reaches of the Yangtze River where water and soil erosion is severe. By participating in afforestation and forest management, local community villagers have not only increased employment opportunities, increased income, and enhanced forest-related cultivation, planting, and management skills, but also greatly enhanced people's awareness of ecological protection, further promoting the national Implementation of rural revitalization strategy. During the implementation of the project, relying on this project, Sichuan launched the forest carbon sequestration industry poverty alleviation technology integration and demonstration project in 2018, exploring new ways to promote targeted poverty alleviation and common prosperity.

Case studies show that forest carbon sequestration projects play a positive role in promoting rural revitalization. By converting forest resources into carbon sink income, local economic development can be promoted and farmers' living standards improved. At the same time, these projects can also protect the environment, maintain biodiversity, and improve the local ecological environment. However, these cases also remind us that the implementation of forest carbon sink projects needs to fully consider the characteristics of the local environment and ecosystem to ensure the sustainability of the project. At the same time, the issue of benefit distribution also needs to be resolved to ensure that local residents can fully benefit from these projects.

3. Results and Discussion

3.1. Current status and problems of forest carbon sink development in Sichuan

3.1.1. Current status of Sichuan forest carbon sink development

Rich in forest resources. Sichuan Province is rich in forest resources and is a national forest city with a forest coverage rate of 37.25%, ranking fourth in the country. In recent years, Sichuan Province has actively promoted the development of forest carbon sinks and continuously increased forest area and carbon sink reserves through measures such as strengthening forest protection and afforestation. Currently, 4 of the 5 domestic CDM afforestation carbon sequestration projects are located in

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Southwest and South China, including 2 in Sichuan, 2 in Guangxi, and one in Inner Mongolia. These projects are just simple afforestation or reforestation projects, and are now gradually extended to include forest and grass carbon sequestration projects with multiple forest effects such as afforestation, biodiversity protection, and community poverty alleviation. The biggest difference and advantage between forest and grass carbon sinks and other energy carbon sink projects is that forest and grass carbon sinks can not only bring carbon sink benefits, but also simultaneously exert afforestation, greening, and ecological management and protection benefits (Wang Daiqiang, 2021).[3]

Forest carbon sinks have huge potential. According to data released by the Sichuan Provincial Bureau of Statistics, the annual fixed carbon content of the province's forest ecosystem is more than 70 million tons, and the cumulative carbon reserves exceed 2.9 billion tons, which can provide land resources for the development of afforestation carbon sinks, bamboo forest carbon sinks, and forest management carbon sink projects. They amount to 510,000 hectares, 700,000 hectares, and 6.8 million hectares respectively. If all carbon sink projects are implemented, carbon dioxide emissions can be reduced by 130 million tons, 120 million tons, and 800 million tons respectively in 30 years. Launched in October 2005, Sichuan Province organized and launched the world's first forest carbon sequestration project based on climate, community, and biodiversity (CCB) standards, an afforestation and reforestation project on degraded land in northwest Sichuan, China.

The ecological value compensation capability is outstanding. In recent years, Sichuan's economy has developed rapidly, but it has also caused serious damage to the ecology. Biodiversity has been seriously affected, and many rare animals and plants are on the verge of extinction. Increasing forest carbon sinks can not only improve ecological governance capabilities, but also play an indispensable role in improving the ecological protection compensation mechanism and improving the ecological barrier function of the upper reaches of the Yangtze River.

Forest carbon sinks develop slowly. The development of forest carbon sink projects in my country is mainly based on carbon sink afforestation projects, supplemented by forest management, and is mainly concentrated in southwest and central China, with Sichuan Province having relatively abundant projects. However, in recent years, the development of forest carbon sinks has slowed down. On the one hand, the National Development and Reform Commission has suspended the registration of CCRC projects; on the other hand, it is difficult to develop afforestation carbon sequestration projects, and it takes a long time from the planting of saplings to the initial results. Moreover, if afforestation activities are carried out on farmland, short-term subsidies are difficult to offset the losses of farmers. , so farmers' support for carbon sequestration projects is also weak.

3.1.2. Problems existing in the development of forest carbon sinks in Sichuan

It is difficult to develop forest carbon sink projects. Forest carbon sequestration projects require complex measurement, accounting, testing, verification and other work. At the same time, project management and monitoring also require long-term tracking and service by relevant professionals. This is a challenge for Sichuan, because our country currently has a shortage of professionals in this area and the technical level needs to be further improved.

Policy support is insufficient. First of all, in terms of capital investment, afforestation, management, and testing all require a lot of capital, and our province's capital investment is far from enough. During the development process of forestry carbon sink projects, carbon sink measurement and monitoring are complicated, and the cost is about 300- 500 yuan/hm2. In order to focus on scale effect, the initial investment to develop a forestry carbon sink project of about 2000 hm2 is at least about 500,000 yuan, which is generally higher than the initial investment of renewable energy emission reduction projects (Zhang Rong et al., 2017) [4]; Secondly, the regulatory authorities also lack unified carbon sink measurement and monitoring standards, making it difficult to compare and evaluate carbon sink transactions between different regions; finally, the government also lacks intensity in promoting forest carbon sinks.

Public awareness is low. Although forest carbon sinks are of great significance for mitigating climate change and protecting the ecological environment, society's awareness of forest carbon sinks is still relatively low, and there is a lack of understanding and attention to the value of forest carbon sinks. This makes the development and promotion of forest carbon sink projects certain difficulties.

These problems existing in the development of forest carbon sinks in Sichuan require the joint efforts of the government, enterprises and all sectors of society to solve. By strengthening technology research and development, raising social awareness, increasing financial investment and policy support, we can promote the rapid development of Sichuan forest carbon sink projects and make greater

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contributions to mitigating climate change and protecting the ecological environment.

3.2. Paths for forest carbon sequestration to help rural revitalization

3.2.1. Promote income through employment

The development and implementation of forest carbon sink projects requires a large amount of manpower, so local unemployed people can be absorbed into the project to create employment opportunities for them and promote rural employment. The development of forest carbon sinks can promote the development of rural economy and increase farmers' income. In the five-county area in the case study, many farmers have gained additional income by participating in forest carbon sequestration projects. For example, some farmers have improved forest quality and management levels and increased forest carbon sinks by planting fast-growing tree species and carrying out forest tending. These farmers not only gain timber benefits, but also carbon sequestration benefits. In addition, some farmers also participate in the carbon sink trading market and earn additional income by selling carbon sink indicators. According to statistics from the Sichuan Provincial People's Government, in the past few years, villagers have earned more than 26 million yuan in labor income from participating in the project, and gained more than 13 million yuan in income from cultivating seedlings. The per capita income of villagers in the project area has increased by about 2,160 yuan. This not only increases income, but also provides benefits to poverty-stricken areas. It has played a very good role in controlling the return to poverty. Forest carbon sinks have played an important role in anti-poverty practices, and poverty reduction is increasingly becoming an integral part of forest carbon sink projects in developing countries (Zeng Weizhong et al., 2017).[5]

3.2.2. Promote improvement through afforestation

The development of forest carbon sinks can also improve the rural environment. In the five-county area in the case, many villages have protected and managed the mountain forests around the villages through the implementation of forest carbon sequestration projects. These measures not only increase forest coverage, but also improve the environmental quality of the village and reduce soil erosion and environmental pollution. At the same time, the development of forest carbon sinks also promotes the protection and management of wildlife and maintains biodiversity. These measures not only improve the environmental quality of rural areas, but also improve the quality of life of farmers.

3.2.3. Promote development with green

The development of forest carbon sinks can promote green development. In the five-county area in the case, the company actively participated in the forest carbon sequestration project. Through afforestation, forest protection, carbon sequestration trading and other measures, it reflected the company's social responsibility for proactive emission reduction and also promoted the company's green development. These companies can not only improve their social image and brand value by implementing carbon sequestration projects, but also promote their sustainable development and innovative development.

4. Policies and suggestions

4.1. Government level

Adhere to the principle of government guidance and market priority. The development of my country's forest carbon sink is still in its infancy, so it requires active guidance from the government. In terms of property rights, since forest carbon sinks have obvious positive external effects, the further development of collective forestry still requires further deepening forest rights reform, and effectively improving the collective forestry operating environment, liberating productivity, and assisting the country’s green and low-carbon development (Xu Jintao et al. , 2022). [6]Therefore, the government should clarify property rights, ensure the sustainable development of forest carbon sinks, and further tap the economic value of forest carbon sinks; in terms of funding, the government should provide corresponding support, whether it is income compensation for farmers or huge forest carbon sink projects. The funding needs require government leadership and support; in terms of publicity, the government should strengthen publicity and actively guide and cultivate the public's awareness of carbon sinks, so that the public will gradually become willing to voluntarily reduce emissions.

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4.2. Professional organization level

In order to ensure the development of forest carbon sequestration projects and fully realize their economic value, professional evaluation institutions need to further unify measurement standards, especially for the measurement of carbon sequestration reserves in different forest types, unify measurement methods and standards as soon as possible, and introduce a set of feasible methods, and standards, actively promote the development of forest carbon sequestration projects, promote carbon sequestration transactions, and promote excellent methodological experience, such as Fujian Province's "One-Yuan Carbon Sequestration" Project Methodology. my country's forest carbon sink transaction costs are high, and the measurement caliber is too narrow, which is also an ongoing problem. On the one hand, the methodology overemphasizes the increased carbon sinks due to additionality; on the other hand, there is still a lack of methodology for natural forest carbon sink projects, which hinders the development of forest carbon sinks (Lü Jinwei et al., 2022).[7]

4.3. Enterprise level

Enterprises, especially financial enterprises, should actively explore the inclusion of forestry carbon sink projects into the scope of green credit and green bonds, promote the development of green financial products to meet the needs of investors, increase the total issuance of forest carbon sink green credit products, and support enterprises through Mortgage forest rights to obtain financing (Lian Xin et al., 2023).[8] Financial companies should innovate and cooperate with relevant departments to innovate green financial products for forest carbon sinks and promote the smooth development of forest carbon sink projects.

5. Conclusions

Forest carbon sink is a significant component of global ecological construction. Sichuan Province is in the backward area of economic development in the central and western regions, where industrial development inevitably leads to an increase in carbon dioxide emissions. To protect the ecological environment while maintaining economic development space, it is necessary to develop a low carbon economy, and developing forest carbon sink is one of the main means to achieve this. Sichuan Province has abundant forest resources, a large contribution to carbon sink capacity, prominent ecological value compensation functions, and high economic value of forest carbon sink, making important contributions to improving local farmers' economic income and the ecological environment. Forest carbon sink is a key mean to solve the contradiction between the ecological demonstration function orientation and economic development in Sichuan Province. Therefore, enhancing the carbon sink capacity of Sichuan's forests and giving full play to the important role of forest carbon sink are key steps in promoting China's dual carbon work, supporting rural revitalization, and achieving the great goals of clear waters and green mountains are invaluable assets and a community with a shared future for mankind.

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ISSN 2616-7433 Vol. 6, Issue 1: 136-141, DOI: 10.25236/FSST.2024.060123

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