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Research on the Innovation and Development of the Internet of Things Forestry Carbon Sink Model from the Perspective of Digital Village

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Abstract: The integrated development of forest carbon sinks and the digital economy can enhance both the rural industrial system and the level of economic development, ensuring the construction of digital villages. However, several challenges arise in actual development. The shortage of financial services in rural areas makes it arduous to meet the demand for industrial upgrading. The forestry carbon sink sector of the Internet of Things is in its initial phase and requires further improvement and support. Hence, it is imperative to enhance the appropriate policies and institutional framework to reinforce the construction of digital villages. This involves strengthening the management proficiency of the digital village and improving the financial channels of the Internet of Things forestry carbon sink industry. It is also crucial to guide the development of the rural digital economy industry through proper policy formulation.

Keywords: Internet of Things; Forestry carbon sequestration; Model development; Rural income; Digital village

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1. Introduction

The introduction of the 2019 Agricultural and Rural Development Plan (2019–2025) aimed to create a digital village, through the development of digital agriculture in the cultivation of rural multi-functional value to accelerate the transformation of the agriculture field and promote the employment of farmers with higher income. The China No. 1 Central Document also clearly states: "To comfortably cope with a hundred years of change and the epidemic of the century, and to promote stable and healthy economic and social development, it is necessary to stabilize the basics of agriculture, modernize rural areas, and then comprehensively promote the revitalization of the countryside, to ensure the stable production of agriculture and increase yields, so that farmers steadily increase their income, and the rural areas are stable and peaceful." Additionally, with the accelerated development of information technology applied to the field of agriculture, the digital economy is developing at an unprecedentedly fast pace, with a wide range of influences, and is becoming a key force in restructuring global factor resources, reshaping the global economic structure, and changing the pattern of global competition [1]. The digital economy is manifesting itself in the form of the modernization of agricultural machinery and the digitalization of agricultural production. Therefore, digital agriculture with the modernization of agricultural machinery and the digitization of agricultural production will play an important role in the promotion of the digital village strategy.

2. Internet of Things forestry carbon sink models and development trends in the context of digital villages

The publication of the Agricultural and Rural Development Plan (2019–2025) points out that the focus of future work in the countryside is the combination of digital technology and traditional agriculture, "the direction of which includes increasing the application of digital technology in the field of rural finance, expanding the three agricultural integration with new technologies, creation of rural digital markets and transactions, and other measures, and regional governments can choose appropriate development paths according to the level of local economic development and agricultural characteristics" [2]. As the digital village policy advances, the Forest C sinks have become an important part of the C emission trading market and are generally considered a market-based eco-compensation mechanism in China [3].

2.1. Internet of Things forestry carbon sink model in the context of digital villages

The Internet of Things forestry carbon sink model responds to the national call to help farmers digitally. The model does not change the original forest land, forest ownership, and right to operate, and does not rely on harvesting forests and selling timber products to obtain economic benefits. The model is a kind of gratuitous compensation for past forestry planting and protection that is conducive to solving the problem of the government being the sole source of funding for forest ecological service, as they might face difficulty in terms of finances. In this system, both parties are committed to forest management activities with the main goal of increasing forest C sequestration in designated lands within a specific contract period, such as 20–60 years in China. Its model is to obtain Chinese certified emission reductions (CCERs) issued by the National Development and Reform Commission (NDRC) through the development of projects such as forestry carbon sinks CCERs as shown in **Table 1**, and then sell them to energy-intensive enterprises to generate revenue.

At present, the measurement methods of forest carbon sinks and carbon offset are mainly divided into two categories. One is to manually inventory the existing biomass and construct emission models with its stock value for projection. This kind of method has been widely applied in China, in which experts and scholars have made dynamic predictions on the development trend of China's forest carbon sink function based on several of China's forest resources inventory data and forest resources system simulation models. Among them, the natural carbon source/sink (NEP) calculation model is widely recognized and used by the academic community. Net ecological productivity (NEP) of vegetation is the portion of net primary productivity after subtracting the photosynthetic products of heterotrophic respiratory losses (soil respiration) [4]. The **Formula 1** is shown below.

$$NEP_{(x,t)} = NNP_{(x,t)} - R_{(h)} \qquad (1)$$

However, the amount of real-time data on soil microbial photosynthetic products cannot be accurately measured. Empirical modeling calculations are commonly used in the academic community instead, as shown in **Formula 2**.

$$Rh = 0.22 \times (\exp(0.0912T) + \ln(0.314R + 1)) \times 30 \times 46.5\% \quad (2)$$

For **Formula 2**, T is the temperature (°C) and R is the precipitation (mm).

This model is based on the real-time collection and uploading of forest ecosystem factor data from sensors erected in the forest. The GLO-PEM model was used to account for $NPP_{(x,t)}$, and using the theoretical basis of a linear relationship between GPP and APAR in terms of light energy utilization (ε), $NPP_{(x,t)}$ can be expressed as shown in **Formula 3**.

$$NPP_{(x,t)} = PAR \times FPAR \times \varepsilon - R_M \quad (3)$$

For **Formula 3**, PAR is the effective photosynthetic radiation, FPAR is the ratio of effective photosynthetic radiation absorbed by vegetation, ε is the realistic light energy utilization rate based on the GPP concept, and R_M is the vegetation autotrophic respiration. The formula for realistic light energy utilization in the GLO-PEM model is as follows in **Formula 4**.

$$\varepsilon = \varepsilon^{*} \times \epsilon_T \times \epsilon_E \times \epsilon_S \quad (4)$$

For **Formula 4**, ε^{*} is the photosynthetic utilization rate of the plant as determined by the sensor, ϵ_T is the coefficient of the effect of air temperature on plant growth, ϵ_E is the coefficient of the effect of atmospheric water vapor on the plant growth and ϵ_S is the coefficient of the effect of soil moisture deficit on plant growth.

Table 1. Major forestry carbon sink projects

Project	Carbon sink afforestation project	Bamboo afforestation carbon sink project	Forest management carbon sink project	Bamboo forest management carbon sink project
Voluntary emission reduction methodology number	AR-CM-001-V01	AR-CM-002-V01	AR-CM-003-V01	AR-CM-005-V01
Release time	11/4/2013	11/4/2013	1/23/2014	2/25/2016
Land category	Not wetland and organic soil	Not a wetland	Mineral soil	Not a wetland or organic soil
Land type	No forest land	-	Artificial young and middle-aged forests	-
Soil disturbance	Comply with soil and water conservation requirements, with the proportion of soil disturbed area not exceeding 10% of the surface area, and not to be repeatedly disturbed within 20 years	Meets soil and water conservation requirements, grasslands, woodlands, percentage of soil disturbed area does not exceed 10% of surface area	Comply with soil and water conservation requirements, the proportion of soil disturbance does not exceed 10% of the surface area and will not be repeated within 20 years.	Meets soil and water conservation requirements
Original forest treatment	No burning	No clearing	Burning is prohibited	No clearing
Deadwood treatment	No removal of dead material on the surface, tree roots, deadwood, and logging residues.	No clearing of pre-existing scattered forest	Deadwood and surface litter may not be removed except to improve sanitation	No removal of deadwood

2.2. Future trends of Internet of Things forestry carbon sinks in the context of digital villages

The nesting and coupling industries are needed to form an industrial chain. This includes the in-depth optimization of the industry, the construction of coupled industries, and the development of digital and low-carbon as the main business philosophy of the forestry carbon sink industry cluster as shown in **Figure 1**. After building the Internet of Things and forestry carbon sink system, the key is to operate, maintain, and develop the industry chain in a long-term and sustainable manner, and to play a comprehensive role in ecological environmental protection, industrial development, and solving the local livelihood of the coupled industry chain. This is to ensure the sustainable development of the coupling program and to solve the contradiction between economic development and ecological protection.

3. Bottlenecks in the development of Internet of Things forestry carbon sinks in the context of digital villages

3.1. Uneven development of forestry carbon sinks, with logging revenues greater than pure carbon sinks in some areas

Overall, China's forestry carbon sink system is still in the exploration and start-up phase of the industry, so the relevant infrastructure and related key technologies have not yet been popularized. The development of the relevant industries in the north and south of the country is not balanced. As shown in **Figure 2**, the national carbon sink production in the south of the country has high potential, while in the north of the country has low potential, showing the potential decreases moving from the south to the north of the country. From the viewpoint of the spatial distribution of forestry vegetation in China, the vegetation ecology of the Northwest region is gradually developing, and the amount of its carbon sink fixation is gradually increasing, so the revenue of the carbon sink industry is not as good as that of the timber-generating forests year-on-year.

For example, a larch C sink project with a 25-year term on a high-productivity site (SI = 19) can generate an additional 1179 CNY/ha (181 USD/ha), relative to timber production forestland. However, **Table 2** also shows that under the current C trading prices in the market, including the minimum price of 3.8 CNY/tCO2e, the mean price of 19.8 CNY/tCO2e, or maximum price of 37.9 CNY/tCO2e, enrolling in a larch C sink project on any productivity sites generates more losses than the timber production forests.

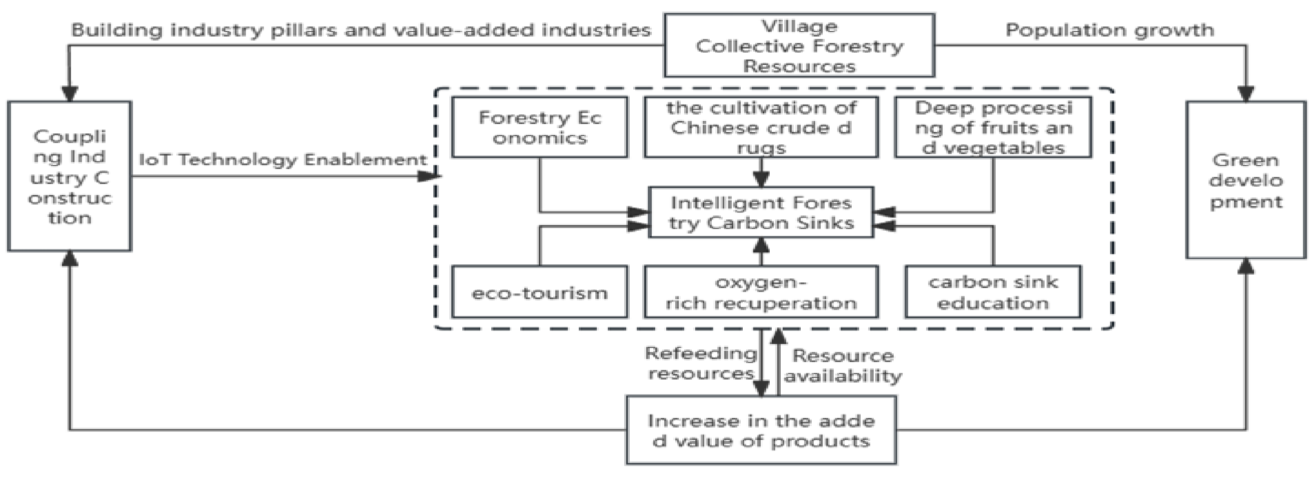

Figure 1. Forestry carbon sink coupling industry chain

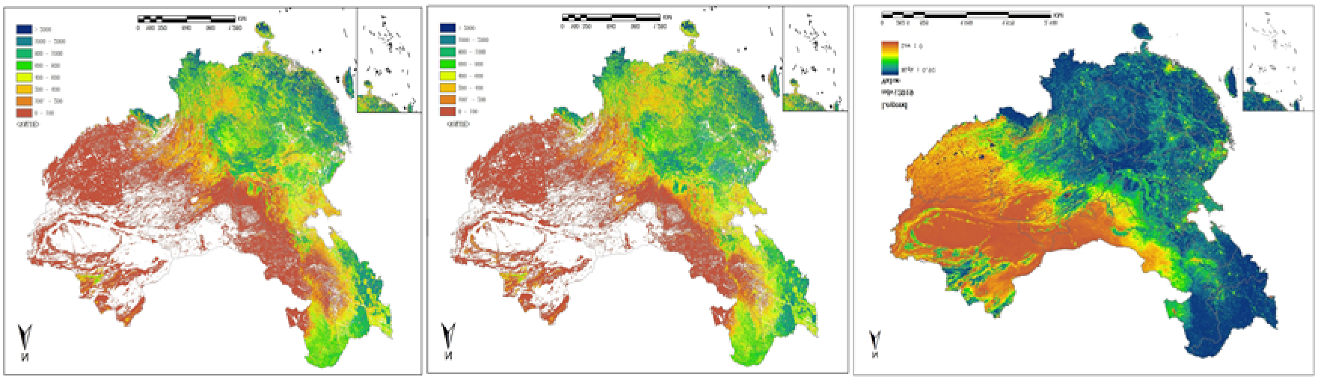

Figure 2. 1 km vegetation index data for China 2001–2015–2019

3.2. The rural and forestry carbon sink industry is still in development

Along with the aging of the rural population, the development of Internet-based digital technology applications in rural areas is lagging, and the phenomenon of the digital divide in rural areas is very significant, so digital technology development has not yet been widely adopted and applied in rural areas. According to the data of the Ministry of Agriculture and Rural Development, by 2022, the proportion of the agricultural digital economy in the value added is only 7.3%, the value of agricultural products retail sales accounted for only 9.8% of the value of agricultural products, and the Internet application rate in rural areas is only 38.4%, which is seriously lower than the national average level. This has caused the development of China's agricultural modernization to lag behind. As of the end of 2022, China's average modernization rate of agricultural production is 25.4%, which is higher than the average of provinces in the agricultural provinces but only accounted for a relatively low percentage of the large provinces, as shown in **Table 2**. Compared to other countries, it is seriously lower than 89.6% in the United States, as digital agriculture developed in the United States and Japan is more than 50%.

Specifically for the forestry carbon sinks industry, China's forestry carbon sinks trading market is still in its infancy, and the trading method is relatively simple. It is mainly traded through the carbon trading platform. The market is divided into the national carbon market and eight regional carbon markets. There are differences in the policies and coverage of each region, which will lead to the transfer of some high-emission industries from the regions with strict policy implementation to the regions with lax policies, which is known as carbon leakage, resulting in the current market transactions being not active. Not only is the trading volume of the carbon market in China much smaller than expected, but the prices in most markets are always low. Low prices make it difficult to realize the full effect. The High-level Committee on Carbon Pricing estimates that to achieve the Paris Agreement, carbon prices need to reach at least $40 to $80 per ton of carbon dioxide, and $50 to $100 per ton by 2030. The low price of the carbon market not only fails to provide incentives for the relevant enterprises but also makes it difficult to achieve the construction of the digital village system.

4. Policy recommendations for Internet of Things forestry carbon sinks in the context of accelerated development of digital villages

In the face of the above development dilemmas, the development practices of many countries in the global perspective have proved that the development of digital agriculture can effectively cope with the above dilemmas. Its launching, development, and wide-scale popularization in China cannot be achieved without the joint participation of the government, enterprises, farmers, and many other individuals. In this regard, the following policy recommendations are proposed based on the above issues.

Table 2. Provinces with agricultural production modernization rates higher than the national average

Province	Rate of modernization of agricultural production (%)
Anhui	52.1
Shanghai	49.6
Hubei	48.5
Jiangsu	48.2
Zhejiang	45.3
Hunan	32.5
Tianjin	30.5
Zhejiang	29.4
Henan	29.3
Hebei	28.5
Guangdong	28.0
Heilongjiang	27.7
Chongqing	26.5

4.1. Improving the policy and institutional system and clarifying the direction and path of development

The rapid development of the Internet of Things forestry carbon sink industry cannot be separated from the national planning of the digital rural development system in the legal policy system. At the legal level, the introduction of relevant rural emerging digital industry regulations should be accelerated. At the planning level, the national ministries and commissions will start the preparation of the smart agriculture industry development plan as soon as possible to further deploy the digital village industry at the macro level of China's digital village industry development strategy and growth path. At the action plan level, the relevant provinces and cities have issued corresponding action plans and policy initiatives to further refine the objectives and tasks of digital village construction, and support the relevant planning and implementation programs, to promote the continuous improvement of the policy and institutional system for the construction of digital villages.

4.2. Seize the current policy dividends to enhance the level of industrial modernization

With the introduction of the Law of the People's Republic of China on the Promotion of Rural Revitalization, the state encourages the construction of agricultural modernization and promotes the construction of digital village as written in the law. The central and local governments have increased policy support for the digital village industry and the rural areas seize the current policy dividend period to accelerate the exploration of regional characteristics of the digital village construction of new models and paths. For the current development of China's Internet of Things forestry, the first task is to increase the forestry carbon sink technology investment and construction of forestry carbon sinks set up for recognition. For example, the government should increase the construction of the basic database of forestry carbon sinks, and accumulate data on the internal conservation, measurement, and planting of forestry under the forest economy in the Internet of Things. This can be achieved by encouraging the use of new software and hardware by relevant enterprises and enhancing the digital economy literacy of relevant practitioners, to further improve the digitization level of forestry carbon sinks in the Internet of Things and ensure the quality of the data on carbon sinks.

5. Summary

Internet of Things forestry carbon sinks in the context of digital villages can reduce the production costs of rural micro and small forestry enterprises, reduce the operational burden, promote the diversification of forestry industry services, directly increase the income level of rural residents, and help to increase the income of farmers by improving the employment level of rural residents, promoting the upgrading of the industrial structure, and improving the distribution of income. The Internet of Things forestry carbon sinks in the rural market can effectively increase the rural industrial structure to increase employment and help rural residents' income growth, so the government must pay attention to its incentive role in the rural economic market, and make better use of it to improve the rural economy. A diversified and dynamic market can continue to attract resources from all walks of life, and can fundamentally solve the resource constraints in the development and revitalization of rural areas, thus providing a strong approach to the strategic goal of rural revitalization.

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Disclosure statement

The authors declare no conflict of interest.

Reference

[1] Xi JP, 2022, Continuously Strengthen and Optimize China's Digital Economy. Seeking Truth, 2022(2): 4–6.

[2] Li MZ, 2022, Research on the Innovation and Development of Rural Digital Supply Chain Finance Model under the Background of Rural Revitalization. Agricultural Economy, 2022(08): 120–122.

[3] Zhang GL, Zhang N, 2020, The Effect of China's Pilot Carbon Emissions Trading Schemes on Poverty Alleviation: A Quasi-natural Experiment Approach. Journal of Environmental Management, 2020(271): 110973.

[4] Pan JH, Yan W, 2015, Estimation of Vegetation Carbon Sinks and their Spatial and Temporal Patterns in the Arid Zone of Northwest China. Journal of Ecology, 35(23): 7718–7728.