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Coordinated development of rural green industry planning based on ecological sustainable model and the internet of things

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Abstract: Although industrial factories can rapidly promote economic development, they have caused significant damage to rural ecosystems. Based on the principle of ecological sustainable development, this paper analyses the characteristics of rural resources and combines IoT sensor technology to develop green industries such as tourism and e-commerce, in order to solve the problems of rural ecological balance and industrial development. This paper compares the situation before and after the implementation of rural green industry planning in Wuyuan County and Haifeng County, respectively. The experimental results show that in Wuyuan County, the average economic growth rate of traditional rural enterprises is 34.08%, while after the implementation of rural green industry planning, this growth rate has increased to 72.04%. In Haifeng County, the average economic growth rate of traditional rural enterprises is 42.04%, but after implementing the rural green industry plan, the growth rate increases to 64.64%.

Keywords: rural green industry; coordinated development; ecological sustainability; internet of things; IoT.

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1 Introduction

In recent years, China's economy has developed rapidly. However, China's economic development is polarised. Industrial technology is the core of urban development, while agricultural products are still the core of rural economic development. As a large agricultural country in the world, China has a large rural population, which provides a large number of labour resources for social development. Rural areas are the main part of China's economic development. However, the imbalance of economic development in

rural areas has become an urgent problem for China's social development. Rural issues are related to China's people's livelihood, and China needs to develop a path of rural revitalisation. China has entered a new stage of the development of a modern socialist country and needs to integrate the concept of green development into rural economic development. Green industry can reduce environmental pollution through new harmless technologies and solve the problems of rural, farmers and agricultural economic development. For example, characteristic tourism industry can be developed in rural areas to give full play to rural pastoral advantages, which can also promote local economic development in rural areas. In addition, the internet of things (IoT) technology can provide technical support for the economic construction of rural green industries and monitor the products of rural green industries to ensure the healthy and efficient development of rural green industries, thus promoting rural revitalisation and achieving common prosperity. Therefore, this paper has research significance.

China's rural and urban economic development differs greatly. The determination of rural characteristic resources, the analysis of rural economic development market and the promotion of rural economic transformation are the main methods to balance the differences between rural and urban development. In this paper, China's rural industry was planned and improved through the ecological sustainable model and the IoT method. The rural green industry was developed and compared with the rural conditions before improvement.

This paper aims to explore the synergistic development path of rural green industry planning under the support of ecological sustainability models and IoT technology. The study first constructs a synergistic development model for rural green industries that integrates ecological carrying capacity assessment and IoT dynamic monitoring. This model collects real-time data on rural environment and industry operation through an IoT sensor network and quantitatively assesses the ecological carrying capacity of villages based on ecological footprint theory, providing dynamic ecological constraints for industry planning. The study further designs a multi-industry synergy mechanism, organically linking green industries such as elderly care, education, e-commerce, and tourism to form a resource-complementary and benefit-sharing industrial ecosystem. In the empirical section, Wuyuan County in Jiangxi Province and Haifeng County in Guangdong Province are selected as case studies. By comparing and analysing multiple indicators, including economic growth rate, ecological environment status, rural reputation, and industrial diversity, under the traditional rural industry model and after incorporating the proposed planning model, the effectiveness of the model is verified. The full text sequentially presents a review of relevant work, methodology construction, experimental design, and results analysis, ultimately demonstrating the positive role of this synergistic development plan in improving the quality of rural economic growth, improving the ecological environment, and promoting industrial diversification, providing a solution with both theoretical innovation and practical value for rural green revitalisation.

2 Related work

The speed of rural economic development is relatively slow, and the use of the special rural environment for industrial development can effectively solve the problem of unbalanced rural development. Many people have studied the rural green industry.

Among them, Chin et al. (2018) pointed out that the way of developing green tourism and green marketing in rural areas could effectively promote the economic development of rural areas and drive the development of other rural industries to a certain extent. Zhang et al.'s (2019) research showed that rural areas were very important in China's economic construction. Rural industry had been developed, and green poverty alleviation and rural revitalisation had been integrated to promote rural green economic development. Wu (2022) analysed the development of rural green industry in Gansu Province of China for two years, and compared the impact of traditional rural industry and rural green industry on rural economy. The results showed that rural green industry could accelerate the speed of rural economic development, which was a feasible method for rural revitalisation. Selwyn (2021) believed that modern rural areas needed to introduce new industries to improve the speed of rural economic development. Rural areas should make full use of rural resources to achieve green industries and improve the balance of rural economic development. The combination of green industry and rural environment can improve the development speed of rural areas.

The development of rural economy cannot be at the cost of environment. Many researchers have applied the theory of ecological sustainability to the coordinated development of rural green industry planning. Among them, Aceleanu (2018) made a comparative analysis of the economic development forms of several rural areas in Romania. He insisted that the rural economy with ecological sustainable development was more stable than the traditional rural economy. Khan (2019) applied the theory of sustainable development to green emerging industries in Asia to strengthen the protection of the environment and improve the relationship between social development and ecological environment with green industries. Yacob et al. (2019) studied more than 200 manufacturing enterprises. Among them, the development of green enterprises was centered on environmental sustainability, which maximised economic development on the premise of ensuring the stability of the ecological environment. The application of the theory of ecological sustainability to the rural green industry can coordinate the development of rural environment and rural economy. However, there is a lack of intelligent construction of rural green industries using technologies such as the IoT.

3 Methods of coordinated development of rural green industry planning

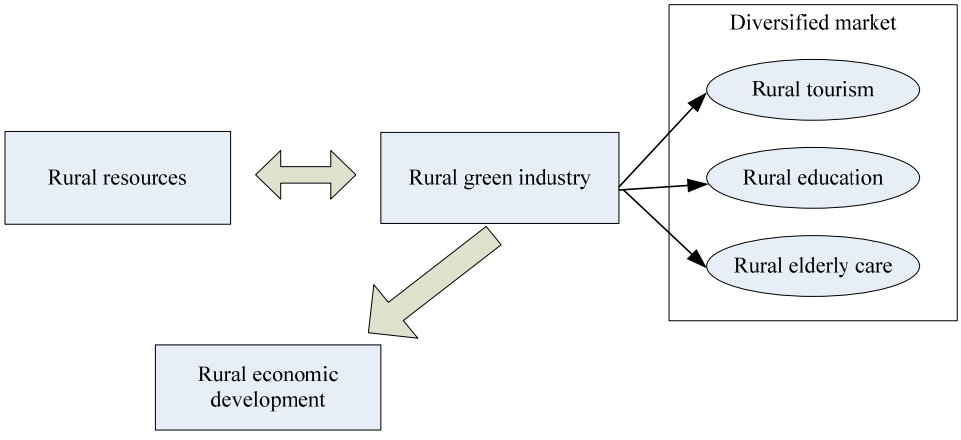
As a socialist country with Chinese characteristics, rural areas are the foundation of China's development. However, the development scale of China's rural areas obviously lags behind the development of urbanisation. After entering the new era of socialism, China needs to strengthen rural revitalisation. On the premise of consolidating the original rural management system, modern agricultural industrial innovation has been carried out to cultivate various forms of rural industrial forms to thoroughly solve the problems of agriculture, rural areas and farmers.

Compared to traditional rural planning methods that mainly rely on static resource assessment and a single industry development path, the model proposed in this paper integrates ecological sustainability and IoT technology to achieve multi-dimensional dynamic monitoring and intelligent management of rural resources. By using IoT sensors to collect real-time environmental and industrial data, combined with an ecological carrying capacity assessment model, the system can dynamically adjust industrial layout and development intensity, avoiding damage to the ecosystem caused by excessive

development. At the same time, the model emphasises the coordinated development of multiple industries, such as organically combining elderly care, education, e-commerce, and tourism to form an industrial ecological chain of resource complementarity and benefit sharing, thereby improving economic benefits while ensuring the sustainability of the ecological environment. This 'data-driven + ecological constraint + industry collaboration' planning model is a core innovation that traditional methods do not possess.

In order to achieve the goal of common prosperity, China needs to achieve high-quality development of rural economy and give full play to the characteristic advantages of rural areas. Through scientific planning, multi-participation and efficient operation, the quality of rural development has been comprehensively improved (Dax and Michael, 2018). Multi-party participation mainly refers to the joint participation of local governments, village representatives, agricultural cooperatives, green industry investors, and third-party environmental assessment agencies in the planning and decision-making process. There are abundant ecological resources in rural areas. Therefore, green industry can be implemented in rural areas, and the coordinated development of green industry and environment can be achieved through industrial planning. The model of coordinated development of rural green industry planning is shown in Figure 1.

Figure 1 Model diagram of coordinated development of rural green industry planning (see online version for colours)



In Figure 1, the model of coordinated development of rural green industry planning is described. The rural green industry constructs a diversified market by utilising the unique resources of the countryside.

China's development and utilisation of rural resources is very low. Rural ecology, culture, mode of production and living habits are valuable resources, and rural industry has great development potential. Rural revitalisation is a complex project, which requires a detailed analysis of the development prospects of rural green industry to create a specific rural market.

The elderly healthcare market is a kind of life needs of the elderly. By giving the elderly a natural, self-sufficient and self-supporting rural living environment, the elderly can cultivate their health in the countryside (Eggleston et al., 2018). In the rural outdoor life, teenagers can understand the hardships of life through working and other ways of

experiencing life, which is conducive to exercise the quality of perseverance. It is a kind of youth education market. In addition, the leisure mode of urban families is diversified, and rural parent-child activities are also a promising market.

The special living environment in rural areas has diversified development markets. The introduction of green industries and the planning of rural industries can effectively promote the development of rural economy to achieve common prosperity.

3.1 Rural green industry

Green industry refers to the active use of cleaner production technology and the reduction of environmental pollution by reducing energy consumption. Green industry has been widely used in ecological protection, economic development and cultural dissemination (Umar, 2022; Guo et al., 2020). The industrial system is the manifestation of centralisation of civilisation. China has gradually developed from a traditional agricultural country to an industrial country, but the damage to the natural environment is huge.

Rural areas are rich in natural resources and unique folk customs. Rural areas have absolute advantages in planting, aquaculture, forestry and rural leisure industries. However, the unique resource advantages of rural areas have not been fully developed. The development status of rural industry is as follows. The farming industry in rural areas mainly includes rice, medicinal materials, vegetables, fruits and melons, etc. There are certain aquaculture industries in areas with sufficient water resources, as well as poultry breeding. The forestry resources in rural areas are relatively rich, but they have not been properly planned. There are leisure industries in some rural areas, but most of them are in the early stage of development and the industrial model is not mature.

At present, the basic industries in rural areas are well developed, with superior natural ecological environment and sufficient rural pastoral elements. The transportation conditions are convenient and the rural areas are interconnected. It is rich in agricultural, forestry and aquaculture resources. It has a long rural farming culture. The tourism market and education market are in great demand.

The industrialisation development of China's rural areas depends on various development opportunities, such as the strategic plan for rural revitalisation realised in China, the cultural and educational opportunities in rural camps, the rural health opportunities brought by the aging population, and the leisure and sightseeing opportunities that meet the tourism needs of young people. Taking the opportunity of China's aging population as an example, the proportion of the elderly in China is increasing, and the quality requirements of the elderly are also changing. The statistical results of China's population aging data in 2020 are shown in Table 1.

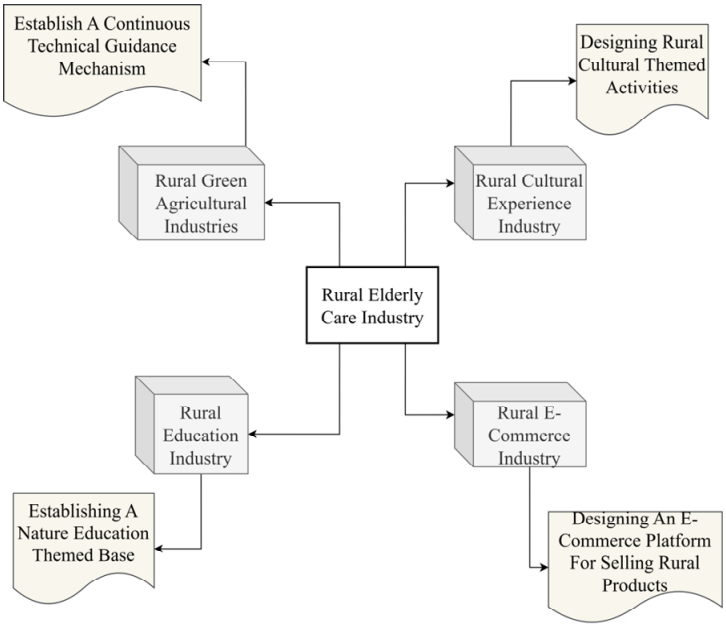
Table 1 Statistical results of China's population aging data in 2020

Region	*Age more than 60 years*	*Age more than 65 years*	*Age more than 80 years*
Nationwide	19.2%	14.3%	2.7%
Rural scope	25.2%	19.1%	2.9%
Urban scope	17.4%	13.3%	2.4%
High school education or above	14.2%	7.9%	0.8%

In Table 1, the statistical results of China's population aging data in 2020 are described. The proportion of the population over 60 years old in China is 19.2%, that over 65 years old is 14.3%, and that over 80 years old is 2.7%. The aging degree of rural population is greater than that of urban population.

Rural e-commerce accounts for the highest proportion of green industries in this survey, driven by its unique environmental friendliness and economic efficiency. On the one hand, the e-commerce model itself does not directly rely on high energy consuming and high emission physical industrial processes, and can achieve long-distance value transmission of rural products with a lower ecological footprint, which is in line with the concept of green and low-carbon; On the other hand, it effectively breaks down the physical barriers between rural areas and markets through digital platforms, enabling small farmers to directly offer their characteristic agricultural products, handicrafts, and even leisure services to consumers across the country, greatly enhancing product added value and economic returns. At the same time, the continuous investment in the national 'digital countryside' strategy and e-commerce infrastructure has provided strong external support for it, making it the most smooth and easily scalable green industry form that links ecological protection and economic development.

Figure 2 Examples of rural pension industry (see online version for colours)



The unique form of rural resources and development advantages are conducive to the development of rural green industry. According to the development advantages of rural areas, the following rural green industries can be constructed.

Rural pension industry: The institutional pension of the traditional pension model should be abandoned, and the environment that makes the elderly feel comfortable should be created. An example of rural pension industry is shown in Figure 2.

In Figure 2, examples of rural pension industry are described. Through comfortable living environment and unique scenery, the rural elderly care environment is created.

Rural education industry: Based on the surrounding rural environment, children are integrated into nature, and natural information is effectively collected, sorted and woven. The nature education theme base should be built (Drescher, 2022; Chen, 2020).

Rural green agricultural industry: based on the existing farmland, unified planning, planting of rape flowers, tea, milkvetch, and various vegetables should be carried out to maintain the original rural landscape and serve as the ecological base for rural leisure tourism. To achieve the transformation from traditional agriculture to green agriculture, it is necessary to systematically conduct training for farmers on ecological planting techniques, operation of IoT equipment, and green product certification standards, and to establish a continuous technical guidance mechanism.

Rural cultural experience industry: Relying on the unique background of the countryside, various rural cultural theme activities can be designed to create rural culture (Ulrich-Schad and Duncan, 2018).

Rural e-commerce industry: Rural products are packaged and e-commerce platforms are designed to sell rural products (Chao et al., 2021; Li, 2021).

3.2 Ecological sustainable development

Sustainable development is to meet people's development needs at the same time, and not destroy the ability of subsequent people to obtain needs (Biermann, 2022; Xu, 2020). Sustainable development refers to the coordination and balance of economy, social resources and environment. While promoting economic development, the protection of the ecological environment also needs to be strengthened.

Rural economic development is based on rural environmental characteristics. Therefore, the premise of green industry planning in rural areas is to implement the strategy of ecological sustainable development. Rural development has entered a new era, and the protection of rural ecological environment is the basis for the realisation of rural modernisation. The structure of rural ecological sustainability model is shown in Figure 3.

In Figure 3, the model structure of rural ecological sustainability is described. The development of green industry is based on rural resources. However, the sustainability of the rural ecological environment needs to be guaranteed and the rural ecological resources should be rationally utilised. A good rural ecological environment is the greatest resource advantage of rural development.

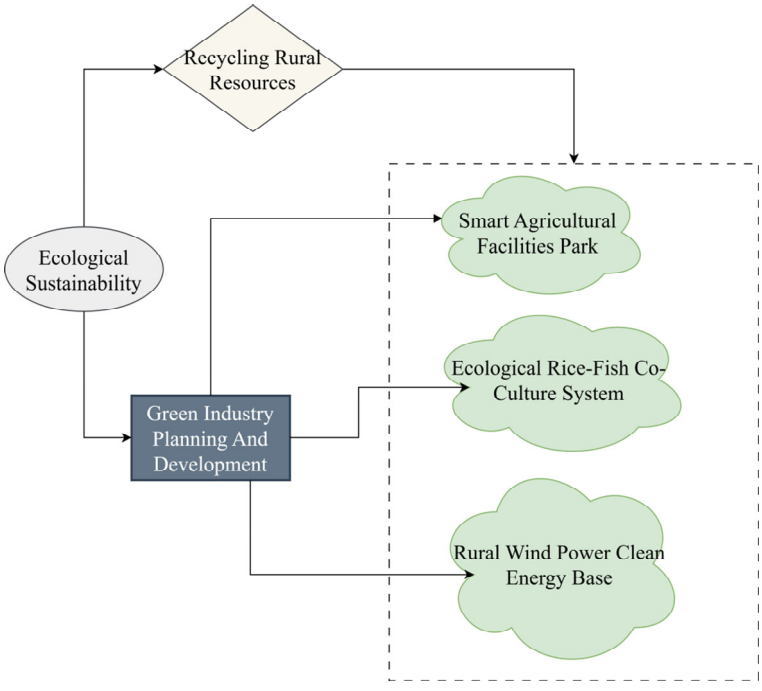
The development of green industries in rural areas can effectively promote economic development. However, at the same time, it also has a certain impact on the local ecological environment in rural areas. It is necessary to fundamentally restrict the development form of non-standard rural industries through ecological and environmental protection strategies. For example, in the rural elderly care industry, the elderly care garden is built to provide a comfortable living environment for the elderly. The rural environment cannot be transformed at will, and the removal of rural forest resources is prohibited. Rural green industry is based on the development of rural resource advantages to promote rural industrial development and realise green industry.

In order to maximise the development of rural ecological resources and vigorously develop rural green industries, it is necessary to calculate the ecological carrying capacity of rural areas. The ecological footprint of rural areas is:

$$EF = M\sum(ai / bi) \tag{1}$$

In formula (1), M represents the population of rural areas. *ai* represents the per capita consumption of the i^{th} resource, and bi represents the natural production of the i^{th} resource. In the ecological footprint calculation model, resource type i mainly covers six key natural capital types that directly affect rural development and ecological carrying capacity: arable land (used for food and economic crop production), grassland (supporting animal husbandry), forest land (providing timber and ecological services), fishery water bodies (providing aquatic products), construction land (carrying human settlements and facilities), and carbon absorption land (used to absorb CO_2 emitted from energy consumption). The selection criteria for these resource types are based on their foundational role in rural socio-economic activities, availability of data, and critical role in maintaining the integrity of rural ecosystems. By quantifying the production and consumption balance of these six types of land, it is possible to systematically evaluate the degree of human activities occupying rural natural capital, thereby providing clear quantitative basis for the ecological sustainability of industrial planning.

Figure 3 Structure of rural ecological sustainability model (see online version for colours)



Then, the natural bearing capacity of rural areas is:

$$EC = M \times ef \tag{2}$$

In formula (2), *ef* represents the per capita ecological footprint.

$$EC = M \sum (c_i \cdot d_i \cdot e_i) \tag{3}$$

In Formula (3), c_i represents the per capita ecological area. d_i represents the yield factor of type i, and e_i represents the resource type.

The basis for judging whether the industrial activities in rural areas exceed the local ecological carrying capacity is:

$$ED = EF - EC \tag{4}$$

In formula (4), ED represents rural ecological surplus.

When the ecological surplus calculation result shows a negative value, the system automatically triggers a hierarchical supervision mechanism: firstly, the IoT platform will lock in the specific resource types and spatial locations of ecological overload based on real-time sensor data, and generate warning information to push to the management department. Subsequently, the system will automatically implement graded interventions based on the severity of overloading, such as automatically adjusting water resource allocation or closing some travel reservation periods for mildly overloaded areas, and automatically suspending the approval of new industry projects and initiating ecological restoration plans for severely overloaded areas. At the same time, the IoT system will continuously monitor and regulate changes in ecological indicators, dynamically optimise industrial operating parameters, and form a closed-loop management of 'monitoring warning intelligent regulation effect evaluation' until the ecology is restored to a sustainable carrying range.

3.3 Application of IoT technology

The IoT refers to the process of collecting information about objects through various sensing devices and sensing technology, and realising information exchange between objects with the help of the Internet to realise intelligent perception of objects (Radwan and Farouk, 2021; Xing et al., 2020). With the development of intelligent technology, the integration of artificial intelligence (AI) and the IoT has become increasingly high, which has accelerated the development of the digital industry. AI can transform the information obtained from the IoT system into useful information through intelligent analysis. In the rural green industry, it is necessary to carry out intelligent management of the industrial form, so as to provide better services for the green industry consumers.

The application model of the IoT in the rural elderly care industry is shown in Figure 4.

In Figure 4, the application model of the IoT in the rural pension industry is described. Through sensor equipment, the temperature, humidity and other information of rural elderly care environment are obtained. After intelligent analysis, appropriate elderly care activities are recommended. The characteristics of rural resources are fully utilised to provide unique elderly care services for the elderly.

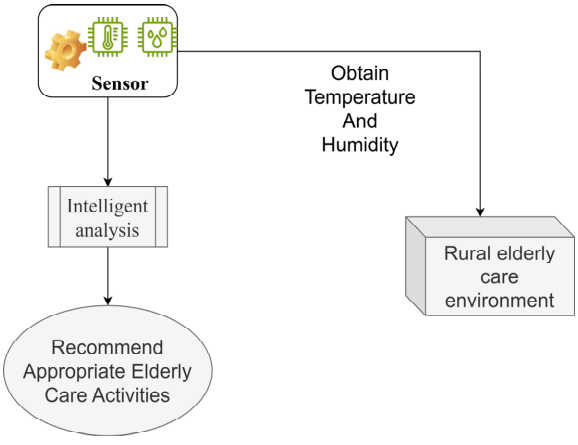
The application field of the IoT is very wide, mainly due to the continuous improvement of sensor equipment, which can collect information from different scenes and accurately measure the water environment, forest environment and air quality in rural areas. In addition, the IoT can also be used to collect information about different rural green industries. After the analysis of cloud computing, the scale of each green industry is reasonably planned and each green industry is coordinated.

The IoT system is used to collect information on the growth of green agricultural products in rural areas, and analyse the cultivation of agricultural products and the harvest date. The time of rural education industry is coordinated, and rural education and agricultural products are integrated. This can not only let tourists experience the planting

and harvesting process of agricultural products, but also play a certain role in rural education.

Rural areas have unique natural resources. The use of IoT technology to fully obtain the advantages of rural resources and targeted development of rural green industry can maximise the development of rural economy.

Figure 4 Application model of the IoT in the rural elderly care industry (see online version for colours)



To ensure effective monitoring and data support for rural green industries, the IoT sensors deployed in this system have set key technical parameters for different monitoring objects. For environmental monitoring (such as air temperature and humidity, water quality pH and dissolved oxygen, soil moisture), sensors with measurement accuracy within the range of ± 2% RH (humidity), ± 0.5 °C (temperature), and ± 0.1 pH (water quality) are used, and the data collection frequency is set to once every 15 minutes to 1 hour according to the dynamic nature of the environment. For monitoring supporting industrial operations, higher precision sensors are selected, and near real-time data collection is implemented for key areas. The establishment of these parameters aims to achieve a balance between data accuracy, system energy consumption, and communication load at a reasonable cost, thereby providing reliable and continuous data streams for the intelligent management and collaborative development of rural green industries. IoT data can be accessed through standardised interfaces to local government decision support systems, enabling real-time sharing of environmental and industrial data and providing dynamic basis for industrial policy adjustments, resource allocation, and ecological supervision.

4 Experiment on coordinated development of rural green industry planning

4.1 Data source of rural green industry

Rural areas have unique geographical location and ecological resources. The development rural resources can promote rural economic transformation and realise rural

revitalisation. When transforming rural industries, the model of urban development cannot be completely copied, and green elements need to be added in the process of rural development. Rural green enterprises are environmentally friendly, and the development of rural green enterprises needs to combine the characteristics of local rural resources. This paper made statistics on 200 green industries in 10 villages in China. Common rural green industry planning schemes are shown in Table 2.

Table 2 Common rural green industry planning schemes

Serial number	*Green industrial form*	*Quantity*	*Percentage*
1	Rural leisure industry	30	15%
2	Rural pension industry	40	20%
3	Camp education industry	34	17%
4	Rural e-commerce industry	52	26%
5	Rural tourism industry	44	22%

In Table 2, common rural green industry planning schemes are described. A total of five common rural green industries were counted, of which the rural e-commerce industry accounted for the highest percentage of 26%.

The planning and development of rural green industry should follow the principle of ecological sustainability, and the local ecological environment should not be damaged while utilising rural environmental resources. When planning the rural green industry, the IoT technology can be used to monitor the information of the rural green industry and provide accurate data for the development of the green industry.

The evaluation system of this study focuses on the macro level evaluation of industrial planning effectiveness, and therefore selects the more comprehensive and data accessible 'ecological environment status' as the core ecological indicator. Although micro indicators such as carbon emissions and biodiversity are scientifically sound, their data is difficult to obtain at the county and rural levels, with high monitoring costs and susceptibility to local non industrial factors, making it difficult to achieve unified quantification in this large-scale questionnaire survey. Future research can supplement these specific ecological parameters through in-depth case analysis, combined with on-site environmental monitoring and life cycle assessment methods, to form more refined evaluation dimensions.

In order to analyse the impact of rural green industry on rural construction, it is necessary to build evaluation indicators for rural green industry planning. Through numerical indicators, the development effect of rural green industry was analysed. This paper conducted a questionnaire survey on 200 rural revitalisation workers. The survey results of the evaluation indicators of the rural green industry planning are shown in Table 3.

Table 3 Evaluation indicators of rural green industry planning

Serial number	*Index*	*Number of people*	*Percentage*
1	Economic growth rate	64	32%
2	Ecological environment	56	28%
3	Rural popularity	36	18%
4	Industrial diversity	44	22%

In Table 3, the evaluation indicators of rural green industry planning are described. A total of four indicators were counted, of which the percentage of economic growth rate was the highest of 32%. The percentage of ecological environment status was 28%, and the percentage of rural popularity was the lowest of 18%.

4.2 Experimental design of rural green industry planning and development

China has a vast territory and different natural resources in rural areas. This paper studied the coordinated development of rural green industry planning in Wuyuan County, Shangrao City, Jiangxi Province, China and Haifeng County, Shanwei City, Guangdong Province, China. Among them, rural revitalisation in Wuyuan County is mainly based on rural resources, mainly through rural tourism and rural e-commerce. The rural revitalisation of Haifeng County is mainly based on water resources, mainly through rural leisure and rural elderly care.

This study selects Wuyuan County in Jiangxi Province and Haifeng County in Guangdong Province as empirical cases, mainly based on their typicality and differences in resource endowment and development models. Wuyuan County is known for its hilly terrain and abundant forest and terrace resources. Its development model of 'rural tourism+e-commerce' represents a typical path for the revitalisation of southern mountainous areas in China relying on ecological and cultural resources. Haifeng County, on the other hand, is located in the coastal area, with rich water and mudflat resources. Its development model of 'rural leisure + healthcare' reflects the characteristics of industrial transformation in coastal areas using unique geographical conditions. The sharp contrast between the two places in terms of natural foundation and dominant industry selection can effectively test the applicability and universality of the planning model proposed in this article under different regional types and resource conditions, thereby enhancing the persuasiveness of the research conclusions.

This paper planned the rural green industry of Wuyuan County and Haifeng County through the ecological sustainable model and the IoT method, and analysed the changes of the countryside before and after the industrial improvement. In order to make a more obvious comparison of the changes before and after the improvement of rural industries, the data of Wuyuan County and Haifeng County before and after the green industry planning were analysed by indicators.

The traditional rural industry mainly sells agricultural products. Based on the ecological sustainable model and the rural green industry planning under the IoT, the green concept was combined with the rural characteristic resources. Under the guidance of the IoT technology, all green industries have been reasonably planned for coordinated development.

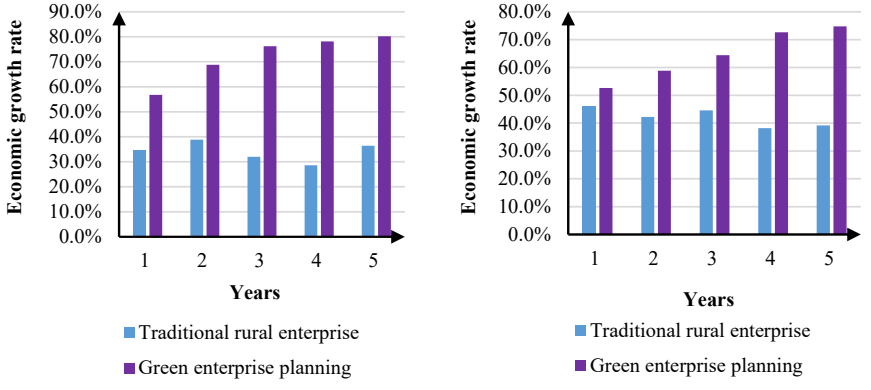
5 Results of coordinated development of rural green industry planning

5.1 Economic growth rate

The most important thing for rural revitalisation is to develop the rural economy. Rural green industry can drive rural economic development through characteristic industrial forms. This paper compared the economic growth rate of Wuyuan County and Haifeng

County before and after the planning and improvement of rural industries. The comparison results are shown in Figure 5.

Figure 5 Comparison results of economic growth rate, (a) economic growth rate of Wuyuan County (b) economic growth rate of Haifeng County (see online version for colours)

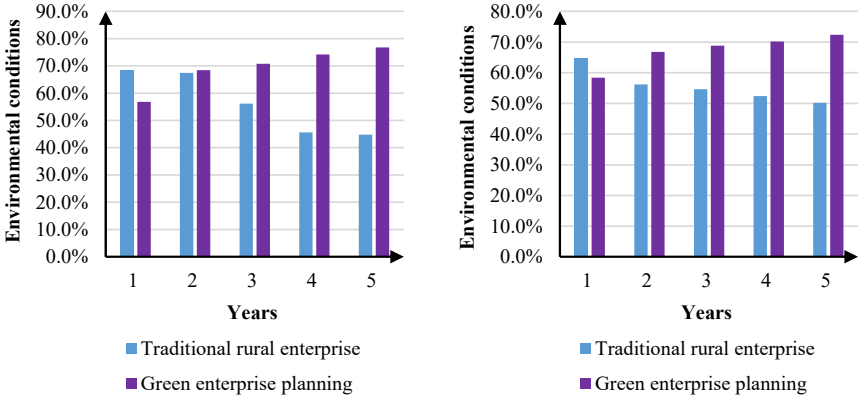


In Figure 5(a), the comparison of economic growth changes before and after the planning improvement of rural industries in Wuyuan County is described. Under the influence of traditional rural enterprises, the economic growth rate of Wuyuan County fluctuated continuously, but the overall change was not significant. The economic growth rate of Wuyuan County under the traditional rural enterprises reached the lowest of 28.6% in the fourth year and the highest of 38.8% in the second year, with an average economic growth rate of 34.08%. The economic growth rate of Wuyuan County increased from 56.8% in the first year of planning improvement to 80.2% in the fifth year, with an average economic growth rate of 72.04%. In Figure 5(b), the comparison of economic growth changes before and after the planning improvement of rural industries in Haifeng County is described. The economic growth rate of Haifeng County under the traditional rural enterprises reached a minimum of 38.2% in the fourth year and a maximum of 46.0% in the first year, with an average economic growth rate of 42.04%. After the improvement of rural green industry planning, the economic growth rate of Haifeng County reached the lowest of 52.6% in the first year and the highest of 74.8% in the fifth year, with an average economic growth rate of 64.64%. Therefore, the coordinated development of rural green industry planning based on the ecological sustainable model and the IoT can effectively improve the rural economic growth rate.

5.2 Ecological environment

Rural economic development is based on rural ecological resources, and the implementation of the rural revitalisation plan cannot be carried out at the cost of ecological environment. This paper compared the rural environmental conditions before and after the planning and improvement of rural industries. The comparison results are shown in Figure 6.

Figure 6 Comparison results of ecological environment, (a) ecological environment of Wuyuan County (b) ecological environment of Haifeng County (see online version for colours)



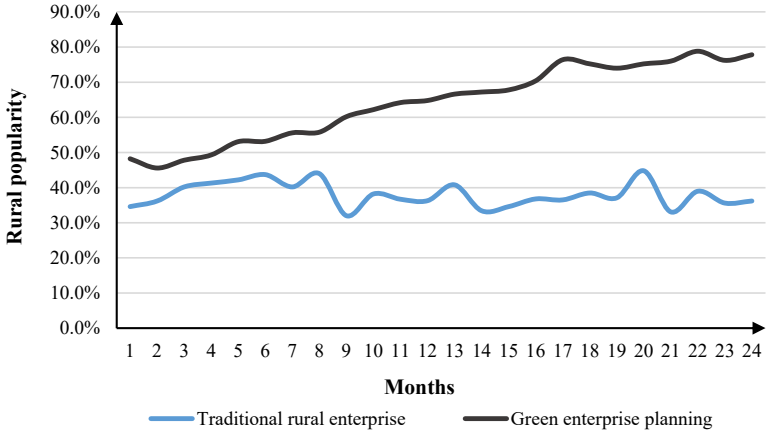
In Figure 6 (a), the comparison of environmental changes before and after the planning and improvement of rural industries in Wuyuan County is described. Under the influence of traditional rural enterprises, the ecological environment of Wuyuan County has been greatly damaged. The environmental condition of Wuyuan County has plummeted from 68.2% in the first year to 44.8% in the fifth year, with an average ecological environment of 56.44%. After the improvement of the rural green industry planning, the ecological environment of Wuyuan County has improved significantly. The environmental situation of Wuyuan County has increased from 56.8% in the first year after the improvement of the industrial planning to 76.8% in the fifth year, with an average ecological environment of 69.40%. In Figure 6(b), the comparison of the changes in the environmental conditions before and after the planning and improvement of rural industries in Haifeng County is described. The ecological environment of Haifeng County under the traditional rural enterprises has also been greatly affected. The ecological environment of Haifeng County has also begun to decline. The ecological environment of Haifeng County has declined from 64.6% in the first year to 50.2% in the fifth year, with an average ecological environment of 55.60%. After the improvement of rural green industry planning, the ecological environment of Haifeng County has also been improved, with an average ecological environment of 67.32%. The five-year experimental period can reflect the initial trend of ecological restoration, but the consolidation of long-term ecological balance requires a longer period of monitoring and assessment. Subsequent studies will extend the observation period to verify the sustainability of ecological restoration. Therefore, the coordinated development of rural green industry planning based on the ecological sustainable model and the IoT can effectively improve the quality of rural ecological environment.

5.3 Rural popularity

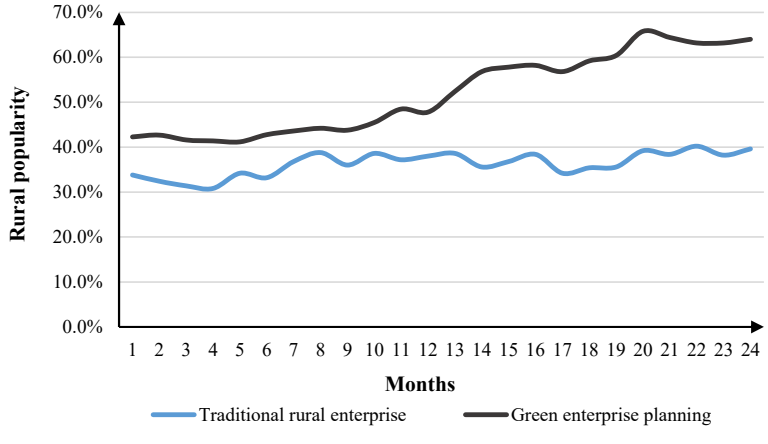
The popularity of villages can reflect the effect of rural industrial planning and development from the side. The higher the popularity of rural areas, the better the effect of rural industrial development can be generally considered. This paper compared the

rural popularity before and after the improvement of rural industry planning. The comparison results are shown in Figure 7.

Figure 7 Comparison results of rural popularity, (a) rural popularity of Wuyuan County (b) rural popularity of Haifeng County (see online version for colours)



(a)



(b)

In Figure 7(a), the change of rural popularity before and after the planning and improvement of rural industries in Wuyuan County is described. Among them, the rural popularity under the traditional rural industrial planning model fluctuated constantly. The rural popularity of Wuyuan County reached the lowest 32.0% in the ninth month and the highest 44.8% in the 20th month, with an average rural popularity of 38.0%. Based on the coordinated development of the ecological sustainable model and the rural green industry planning under the IoT, the rural popularity of Wuyuan County reached the lowest of 45.6% in the second month and the highest of 78.8% in the 22nd month, with an average rural popularity of 64.23%. In Figure 7(b), the comparison of the changes in rural popularity of Haifeng County before and after the planning improvement of rural industry is described. Under the traditional rural industrial planning model, the rural popularity

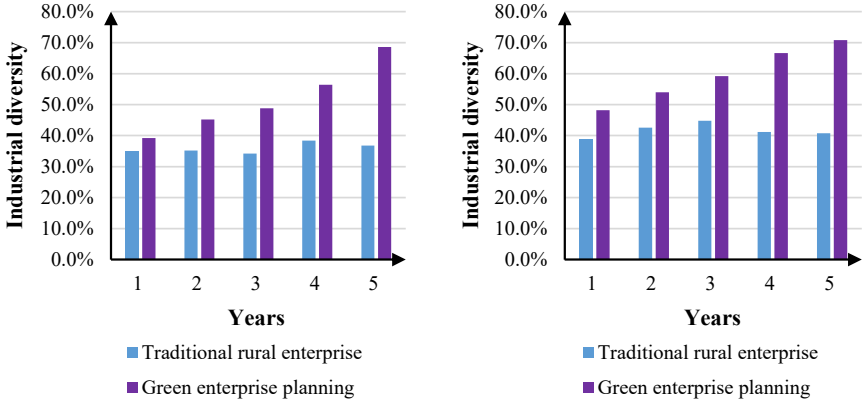
reached a minimum of 30.8% in the fourth month and a maximum of 40.2% in the 22nd month, with an average rural popularity of 36.31%. Based on the coordinated development of the ecological sustainable model and the rural green industry planning under the IoT, the rural popularity of Wuyuan County reached a minimum of 41.2% in the fifth month and a maximum of 65.8% in the 20th month, with an average rural popularity of 51.98%.

The reason for the relatively low increase in popularity index of rural areas in Haifeng County is mainly due to the comprehensive influence of its industrial characteristics and location conditions. Compared with the broad public appeal formed by rural tourism and photography culture centred on visual landscapes in Wuyuan County, the target customer group of Haifeng County's health and leisure industry based on water resources is more segmented (mainly targeting middle-aged and elderly people and rehabilitation groups), and the market diffusion speed is relatively slow; At the same time, Wuyuan County, with its mature 'China's most beautiful countryside' brand effect and location advantage adjacent to the core customer source areas of the Yangtze River Delta, is more likely to receive sustained attention and attract customer flow. Meanwhile, Haifeng County is still in the cultivation stage in terms of brand awareness and customer market radiation, resulting in a longer period of popularity accumulation and relatively flat growth rate.

5.4 Diversity of industries

The rural revitalisation plan is to solve the problem of rural development. The introduction of enterprises through rural resources can promote rural economic development. However, according to the characteristics of rural resources, different types of industrial forms need to be introduced. The diversity of rural industries is the external manifestation of rural development. The higher the diversity of rural industries, the better the effect of rural industrial planning and development. This paper compared the diversity of rural industries before and after the planning and improvement of rural industries. The comparison results are shown in Figure 8.

Figure 8 Comparison results of industrial diversity, (a) industrial diversity of Wuyuan County (b) industrial diversity of Haifeng County (see online version for colours)



In Figure 8(a), the comparison of industrial diversity changes before and after the planning improvement of rural industries in Wuyuan County is described. The industrial diversity under the traditional rural industrial planning mode reached a minimum of 34.2% in the third year and a maximum of 38.4% in the fourth year, with an average industrial diversity of 35.88%. Under the influence of the concept of ecological sustainability and the technology of the IoT, the industrial diversity of the planning and development of rural green industries has been continuously improved. The industrial diversity reached a minimum of 39.2% in the first year and a maximum of 68.6% in the fifth year, with an average industrial diversity of 51.64%. In Figure 8(b), the comparison of industrial diversity changes before and after the planning improvement of rural industries in Haifeng County is described. Under the traditional rural industrial planning model, the industrial diversity reached a minimum of 39.0% in the first year and a maximum of 44.8% in the third year, with an average industrial diversity of 41.68%. After the planning and development of rural green industry, the industrial diversity has been continuously improved. The industrial diversity reached a minimum of 48.2% in the first year and a maximum of 70.8% in the fifth year, with an average industrial diversity of 59.76%. Therefore, the coordinated development of rural green industry planning based on the ecological sustainable model and the IoT can effectively improve the diversity of rural industries.

5.5 Discussion

There is a serious imbalance in China's economic development. Urban development is fast and resources are well utilised, while rural economic development is very slow. The key construction of rural industries is the main means for China to achieve common prosperity. Rural areas have superior natural resources and rural elements. Under the principle of ensuring the sustainability of rural ecology, green industry has been introduced to realise the transformation and upgrading of traditional agriculture. According to the characteristics of rural resources, green pension industry, camp education industry and rural e-commerce industry can be built. Information monitoring of rural green industry through the IoT technology can reasonably carry out industrial planning and improve the degree of coordinated development of rural green industry. This paper constructed the evaluation system of rural green industry planning through questionnaire survey, and compared Wuyuan County and Haifeng County before and after the improvement of rural green industry planning. The results showed that the green industry planning under the influence of ecological sustainable model and IoT technology has effectively improved the speed of economic growth and the quality of ecological environment, and expanded the popularity of rural industries. To avoid the risk of homogenisation in green industries, it is recommended to establish an industry differentiation assessment mechanism based on regional resource characteristics, and to use IoT data to provide real-time early warning of redundant construction in industries, thereby guiding local areas to develop distinctive and complementary industrial layouts. However, this paper only makes a comparative analysis of Wuyuan County and Haifeng County in the planning of rural green industry, and the rural target data analysed are not many.

It should be pointed out that the effective implementation of rural green industry planning highly relies on supporting policies and institutional environment. The success of this research case is attributed to key driving forces such as the guidance of the

national rural revitalisation strategy, special financial subsidies from local governments, and preferential land policies. However, in the broader promotion process, there are still significant institutional obstacles, including: poor mechanisms for cross departmental collaborative management, uncertain entry barriers and investment returns for social capital into the rural green industry, and inadequate rights protection systems for small farmers to integrate into the modern green industry system. Therefore, the future development of rural green industries not only requires optimisation of technical models, but also urgently needs to establish cross departmental coordination mechanisms, innovate green financial tools, and improve interest linkage mechanisms at the policy level, in order to clear institutional barriers for the implementation of planning and achieve sustainable rural revitalisation.

6 Conclusions

The model constructed in this study has taken into account the impacts of different climates and geographical regions, and its applicability is based on a universal framework of 'ecological carrying capacity industrial function technological empowerment'. The core of the model is to dynamically perceive the specific resource endowment of a region through the IoT and input it into localised ecological footprint parameters for calculation, ensuring that industrial planning always takes the local ecological red line as the premise. Therefore, this model is not a single solution, but an adaptive methodology that can adapt to different geographical conditions. By adjusting the combination of industry types and technology monitoring priorities, it can maintain its scientific and feasibility in diverse climate and geographical environments.

Declarations

All authors declare that they have no conflicts of interest.

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