

# Analysis on the protection and sustainable development of traditional villages and towns based on low-carbon thought: A case study of traditional low-carbon design thought to optimize sustainable development of villages and towns in Jiangnan, China

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**Abstract.** Under the background of rural revitalization, the important goal is to help the sustainable development of villages and towns. While implementing the concept of green development, development needs to promote the inheritance and continuous activation of rural culture. In this paper, the ancient architectural wisdom and green design concept contained in the traditional houses in the south of the Yangtze River were studied, and how to extract the low-carbon ideas and combine them with modern green technology to achieve the parallel development of villages and towns and the preservation and promotion of traditional culture was explored. The research results also provide new ideas for village development and cultural heritage in a carbon-neutral context.

**Keywords:** Low carbon thought, Village and town protection, Jiangnan Watertown Residence, Cultural heritage.

## 1. Introduction

With the proposal of China's goal of carbon neutrality and the promulgation of relevant policies and measures, the development of villages and towns is facing the difficult problem of low-carbon sustainable transformation. Recently, the Opinions of the CPC Central Committee and the State Council on the Complete, Accurate and Comprehensive Implementation of the New Development Concept to Do a Good Job of Carbon Neutralization in peak carbon dioxide emissions and the Action Plan of peak carbon dioxide emissions before 2030 issued by the State Council clearly put forward that villages and towns should also carry out low-carbon construction in rural areas. At present, the low-carbon transformation of villages and towns in China is still seriously lagging behind, and there is still a long way to go in terms of scientific and technological guidance, government funding guarantee and implementation plan according to local conditions.

In the research of existing scholars, the relationship between carbon emissions in villages and towns and agriculture, tourism and other industries is discussed and a model system analysis was established. Wu et al. (2022) built a carbon emission measurement model, systematically analyzed the carbon emissions of various villages and towns via putting forward the concept of rural "carbon map". Guo et al. (2012) studied the energy system of Hollow Village and discussed the low-carbon strategy of comprehensive renovation of Hollow Village. Wei and Huang (2015) pointed out that the construction of "beautiful countryside" needs to meet the requirements of low-carbon development of rural tourism and put forward relevant solutions. Chen et al. (2010) proposed to solve the problem of low-carbon rural construction from two aspects of rural production and life. Liu et al. (2016) analyzed the main factors that influence farmers' willingness to participate in low-carbon rural construction through investigation and model demonstration, and put forward different development perspectives for low-carbon transformation of villages and towns. Wu (2019), based on the types of rural material resources and the characteristics of building structure, conducted in-depth discussions on the factors restricting the low-carbon rural buildings and put forward the low-carbon transformation scheme of rural buildings. Previous scholars mainly focused on the overall low-carbon development strategy of villages and towns, lacking the research and practice in the field of low-

carbon landscape and building construction in villages and towns, and also lacking the targeted research on low-carbon technologies and low-carbon influencing factors, and the related low-carbon construction strategies put forward are also slightly limited.

In addition, some scholars have studied the low-carbon transformation of rural landscape environment. For example, Xing and Zhang (2016) put forward some suggestions on landscape design and planning of new countryside, such as using native tree species for plant allocation, from three aspects of new countryside road, lighting and greening. Ding (2011) started with the analysis of the current rural environment, combined with the low-carbon concept, put forward the low-carbon strategy of rural environment and landscape construction, and put forward suggestions for building a sustainable countryside. This paper provides ideas and methods for the research of low-carbon township construction practice.

The "14th Five-Year Plan" of the central government points out that to promote the sustainable development of agriculture and rural areas, firmly establish the Lucid waters and lush mountains are invaluable assets concept, take the road of sustainable development with resource conservation and environmental friendliness, and at the same time emphasize that to promote the modernization of agriculture and rural areas, we must base ourselves on the regional characteristics of rural areas. The unique traditional low-carbon thought contained in the traditional villages and towns is a powerful means to realize the sustainable development of villages and towns according to local conditions. However, at this stage, the traditional low-carbon thought has not been well practiced in the modern township reconstruction and construction, and its role in promoting the protection and inheritance of township culture needs to be further explored. This study is based on the low-carbon thought contained in the traditional settlements in the south of the Yangtze River, using traditional wisdom according to local conditions, and combining modern green technology in the transformation of villages and towns, so as to promote the protection and sustainable development of villages and towns' architecture and landscape environment in an all-round way.

## 2. Research overview

### 2.1 Policy background

In recent years, villages and towns have developed rapidly under the background of rapid urbanization, and with the pursuit of sustainable development, in the process of village and town construction, the central government's policy guidance for beautiful countryside construction is constantly updated and developed (see Table 1).

**Table 1.** Policies related to sustainable rural development in China.

Meeting policy	Key concepts
2009.01 Notice of the Ministry of Housing and Urban-Rural Development and the National Tourism Administration on the Demonstration Work of Famous Towns (Villages) with National Characteristic Landscape Tourism	Putting forward the national characteristic landscape tourism demonstration towns (villages) is conducive to protecting the natural environment, pastoral landscape, traditional culture, national characteristics, characteristic industries and other resources of villages and towns.
2018.01 Opinions of the CPC Central Committee and the State Council on Implementing the Rural Revitalization Strategy	Implement the rural revitalization strategy, adhere to the comprehensive rural revitalization, adhere to the harmonious coexistence between man and nature, and adhere to local conditions and step by step.
2021.11 "The 14th Five-Year Plan for Promoting Agricultural and Rural Modernization"	Adhere to building for farmers, follow the law of rural development and construction, and pay attention to protecting rural features.

However, due to the limitation of economy and traffic, the quality of the living environment in villages and towns is generally not high. Under the background of advocating green, the layout and

residence under the low-carbon idea is the inevitable trend of the transformation and development of the existing traditional houses in villages and towns.

## **2.2 Development status of green villages and towns at home and abroad**

At present, foreign countries have made some successful cases in the field of low-carbon villages and towns, such as Fenhong Ecological Village in Finland, urban and rural areas in Mengshao, Germany, etc. These villages and towns adopt different low-carbon technologies, including "passive solar energy", wind power generation, rainwater reuse, town landscape zoning based on natural resources, etc. Although they are all low-carbon residential ecological villages, there is still a big difference in the applied technologies.

However, there is no successful case of rural low-carbon in China at present, and it is urgent to obtain some research results and demonstrations in the field of low-carbon rural construction. Through the organic combination of low-carbon technology and rural projects, this paper studies how low-carbon technology can adapt to the village environment where the indigenous people in villages and towns live with traditional low-carbon ideas, and explores how modern low-carbon strategies and traditional low-carbon ideas can jointly promote the new vitality of traditional villages and towns in the background of rural revitalization, thus providing guidance for the practice of sustainable development in villages and towns.

## **2.3 Present situation of traditional houses in Jiangnan**

Jiangnan water town area is a region with unique humanistic characteristics in China, and it is also one of the regions with relatively developed economic level in China's villages and towns. In the long-term development of this area, the traditional dwellings which are highly harmonious with the local natural climate and cultural characteristics have gradually formed. Most of these houses are in the form of building houses by water and plastering walls with tiles, which constitute the characteristics of houses in Jiangnan water towns with humanistic connotations. However, with the economic and social development and modernization transformation in this region, residents' demand for residential comfort is increasing, which leads to the increasing residential energy consumption. On the other hand, in terms of architectural form, the newly-built village houses are separated from the traditional houses in the south of the Yangtze River, the traditional texture of the water towns in the south of the Yangtze River gradually disappears, the traditional architectural features disappear completely, and the historical context passed down from generation to generation has not been well inherited and developed.

## **3. Low-carbon thoughts of traditional houses in Jiangnan**

Traditional folk houses in the south of the Yangtze River are unique in Chinese traditional regional architecture. Under the condition of no air conditioning equipment, the construction methods of residential houses in the south of the Yangtze River have developed and gradually formed a set of passive green technologies to cope with the local climate. Among them, low-carbon ideas include making full use of local climatic conditions, paying attention to the location and layout of residential houses, micro-climate adjustment, adopting local building materials, energy-saving construction technology, etc. These precious traditional low-carbon construction methods are worth carrying forward in the sustainable transformation of existing villages and towns in the south of the Yangtze River.

### **3.1 Traditional settlement site selection**

Most of the traditional houses in the south of the Yangtze River are located in the plain, where the water network is densely distributed. Therefore, its settlement site selection follows the Pingyang Feng Shui pattern, with mountains instead of water, and the land surrounded by meandering water as the auspicious place. From the perspective of modern architecture, this site selection is beneficial to

defense and sailing. On the other hand, this site selection form is easy to form land-water breeze, reduce summer temperature and bring refreshing southeast wind, thus creating conditions for local adjustment of microclimate in villages and towns. Moreover, the environmental pattern of the site selection is relatively compact, and when the front-back spacing is 15 m and the left-right spacing is 6 m, the balance of ventilation, lighting and solar radiation can be achieved (Xi, 2022).

### 3.2 Microclimate regulation

Jiangnan's climate is hot and humid in summer and cold in winter, so it is difficult to achieve high indoor comfort in certain periods of a year. In view of the unsuitable climate, traditional dwellings usually adopt the way of adjusting the local microclimate around the dwelling. Traditional methods mainly include reasonable arrangement of water around the house, reasonable planting, etc.

Green plants are widely distributed in traditional houses in the south of the Yangtze River, and their transpiration can regulate the temperature and humidity of the surrounding microenvironment. Deciduous plants planted on the south and west sides of houses are excellent variable shading systems, which can block a large amount of solar thermal radiation in summer. Under extreme conditions, the surface of traditional houses covered with climbing plants can reduce the wall temperature by more than 5 °C. In winter, the falling leaves of plants can make houses receive direct solar radiation, and the heat loss of buildings will be reduced by more than 30% due to plant cover. In addition, the reasonable layout of plants around residential buildings can guide the direction of wind to a certain extent, promote indoor air circulation, and achieve the effect of automatic fresh air (Yang et al., 2020).

Considering the joint action of water body and plants, under the same action of water body, the temperature in dense plant area decreases by 0 °C~5 °C, and the humidity is higher than 0~10%, which significantly improves human comfort. Therefore, the traditional folk houses in Jiangnan, which combine the two, have a suitable climate and meet the requirements of sustainable development of villages and towns (Huang et al., 2020).

### 3.3 Low-carbon building materials

Rammed soil, bamboo, reed, straw and brick are used as building materials in traditional houses in the south of the Yangtze River. Most of these materials are natural materials that are locally available and convenient to transport or processed from natural materials, which meet the relevant requirements of sustainable development for the application of building materials while forming a unique architectural form.

Rammed-earth residence has good building thermal performance, which can achieve the effect of warm winter and cool summer. In addition, in order to enhance the thermal insulation performance of hollow brick walls, traditional dwellings in Jiangnan usually fill the hollow brick walls with raw soil to improve the thermal insulation performance. The cultural genes and material characteristics contained in rammed earth are worthy of inheritance and development, and rammed earth buildings incorporating modern technology and design will surely help the sustainable development of villages and towns and meet the aesthetic needs of modern people (Liang, 2021).

Brick and tile are widely used building materials in Jiangnan folk houses, and they are also the necessary materials for traditional folk houses in Jiangnan to form the architectural characteristics of powder wall and tile. Although the composition of brick is natural, the production of clay brick has been restricted in modern building construction because of the consumption of a large amount of fuel resources and soil in the firing process, which is harmful to the ecological balance and stability. Bricks and tiles in traditional houses in the south of the Yangtze River should continue to be recycled, and the common laying method of tile roofs is cold booth, which is convenient for reuse. Only a small amount of damaged tiles need to be supplemented to continue to be used.

### 3.4 Energy-saving structure

The roofs of traditional folk houses in the south of the Yangtze River are mainly composed of cover tiles and watchbricks under the tiles. There is a certain gap between the watchbricks and the

cover tiles, which can form a thin air interlayer. Through this measure, the temperature difference between the cover tiles and the watchbricks reaches about 10 °C, which makes the air above and below the roof not completely isolated but in a dynamic flow. This structure is beneficial to the thermal insulation and cooling of the roof. At the same time, the ceilings under the roofs of residential houses in the south of the Yangtze River are usually relatively high, which is beneficial to the natural ventilation in the whole house (Yang et al., 2015).

**Table 2.** Summary of traditional low-carbon thoughts of Jiangnan folk houses.

Low carbon measures	Specific method	Effect
Traditional settlement site selection	Follow the Pingyang Feng Shui pattern, replace water with mountains, take the land surrounded by curved water, and the site selection pattern is compact.	It is easy to form land-water breeze, reduce the summer temperature and bring refreshing southeast wind, so as to create conditions for local regulation of microclimate in villages and towns.
Microclimate regulation	Reasonable planting, rational distribution of plants, and reasonable arrangement of water around the house.	Plants regulate the temperature and humidity of the surrounding microenvironment, guide the direction of the wind to a certain extent, circulate and update the indoor air; By absorbing and releasing heat, the water body can achieve temperature suitability adjustment.
Low carbon building materials	Natural materials, such as rammed earth, bamboo, reed and straw, which are available locally and convenient to transport, are used as building materials and brick and tile materials are recycled.	Rammed-earth residence has good architectural thermal performance, which can achieve the effect of being warm in winter and cool in summer. It inherits and develops the traditional architectural forms in the south of the Yangtze River while developing sustainably.
Energy-saving structure	The external walls of traditional houses in the south of the Yangtze River are mostly plastered with bucket walls, which are often filled with soil. There is a certain gap between the roof tile and the cover tile, which can form a layer of air interlayer, and the ceiling is often high.	The hollow wall saves bricks, has light self-weight, good heat insulation and sound insulation performance, and enhances the heat insulation performance of the wall; The air interlayer is beneficial to the thermal insulation and cooling of the roof, so that the air between the roof and the roof is in a dynamic flow.

Traditional folk houses in the south of the Yangtze River have gradually developed under the historical condition of no air conditioning and other regulating equipment, which contains abundant passive low-carbon technologies (see Table 2), which is worthy of our inheritance and development in the sustainable transformation of villages and towns today. These low-carbon strategies are reflected in every stage of housing construction: firstly, in the site selection stage of housing, make full use of the favorable conditions of the place, build by the water, adjust the local climate by natural wind, and create a basic sustainable living environment; Secondly, in the process of building a house, the microclimate in the house is improved by the organization of water body, plant configuration and natural ventilation. In the aspect of subsequent building material selection, local natural building materials are selected and original building materials are fully utilized. In the aspect of overall construction, using the principle of climate buffer, design climate buffer space to improve the comfort of living environment; On the structural level, the walls, roofs, ceilings and other structures of traditional houses in the south of the Yangtze River also contain low-carbon ideas. This set of low-carbon experience of traditional housing construction is worthy of our use in the sustainable transformation and development of existing villages and towns.

#### **4. Low-carbon thought and modern green technology combined development methods to explore**

On the basis of analyzing the traditional low-carbon thought, it is passed down and applied in the reconstruction of Jiangnan water towns, and combined with modern green technology, it helps the modernization and sustainable development of towns and villages in Jiangnan water towns. Most of the traditional low-carbon ideas are based on building materials, construction techniques and location layout. At present, there are many applications of recyclable environmental systems, advanced green building construction methods and digital intelligent platforms in the transformation of villages and towns. The author will discuss how these advanced technologies and traditional low-carbon ideas in Jiangnan water towns can help the comprehensive and sustainable development of villages and towns together.

##### **4.1 Low-carbon Landscape and Sponge Township Building**

There are many waterscapes in the south of the Yangtze River, and the function of water contained in its low-carbon thought is mainly reflected in the micro-climate regulation. Combined with the modern sustainable landscape transformation, the lotus pond, drainage ditch and wetland in traditional villages are transformed into infiltration drainage ditch, ecological lotus pond and rainwater wetland, thus forming a three-level series three-dimensional ecological wetland system with the functions of collecting, transmitting and purifying surface runoff.

Rainwater wetland is the main embodiment of ecological landscape design. A cascade rainwater wetland is built around the lotus pond, which consists of two parts: water system and aquatic system. By enriching wetland species and reasonably matching plant communities, a multilevel water purification system is constructed to form an ecological and natural sustainable wetland landscape in villages and towns.

Actively integrate into the smart landscape to help the sustainable development of villages and towns, install water level sensors and water quality sensors at the core of lotus pond and rainwater wetland, automatically sample and analyze water quality data, detect the running state of wetland system in real time and make appropriate feedback, so as to achieve better climate and ecological environment adjustment effect.

##### **4.2 Retain the texture of native ancient villages and use low-carbon construction technology**

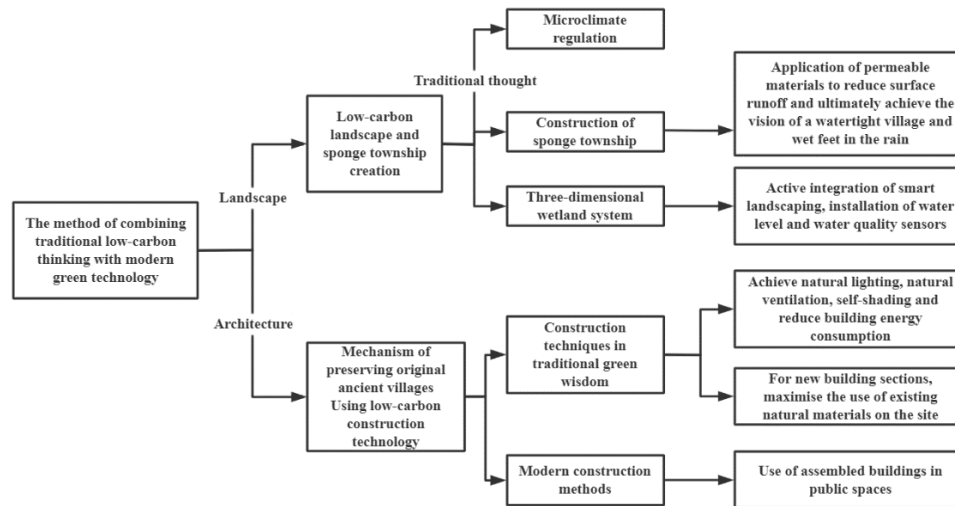
Protect the traditional river form of villages and towns in the south of the Yangtze River and the characteristics of water towns built beside the water to the greatest extent. In terms of architectural style, the diversity of architectural style should be protected, and the preserved ancient buildings should be sustainably protected and repaired, and their decorations, patterns, colors and structures should be maximally retained and utilized to protect the traditional architectural features in the south of the Yangtze River.

At the same time, in the process of building renovation, low-carbon construction technology should be applied. Flexible use of traditional green wisdom construction techniques to achieve natural lighting, natural ventilation, self-shading and other effects, reducing building energy consumption. For the newly-built building part, maximize the use of the original natural materials of the site.

In terms of construction methods, for the rest spaces in public places, such as pavilions and villagers' homes, prefabricated buildings can be combined with traditional construction techniques, which can greatly reduce the generation of construction waste in low carbon, and will not produce dust and waste materials, thus reducing the pollution to the environment. At the same time, in terms of cultural protection, the architectural features of Jiangnan water towns can be preserved, and the traditional low-carbon wisdom can be inherited and carried forward.

As shown in Fig. 1 (Li et al., 2015; Wang and Wang, 2015; Wang et al., 2016; Wu et al., 2016; Zhong et al., 2019; Zhang et al., 2021), the sustainable transformation of villages and towns in the south of the Yangtze River should not be confined to the stacking of energy-saving technologies of

single buildings, but should regard the villages as an organic whole, extract and analyze the regional green technologies in the traditional houses in the south of the Yangtze River, and combine modern low-carbon technologies to explore a sustainable development mode suitable for the south of the Yangtze River.



**Fig. 1** Low-carbon ideas and technology application methods for rural sustainable development.

## 5. Conclusion

The sustainable and healthy development of villages and towns needs the implantation of green technology, and more importantly, it needs to dig deep into the traditional low-carbon ideas contained in it, protect and restore the traditional villages and towns in the process of development, and devote ourselves to continuing the local architectural culture and realizing the characteristic development of villages and towns according to local conditions. Actively extract passive energy-saving strategies from traditional residential buildings in the south of the Yangtze River, such as microclimate regulation, natural ventilation, climate buffering and other strategies, which will not only help to carry out the sustainable transformation of traditional township buildings in the south of the Yangtze River, but also reproduce the architectural features of traditional areas in the south of the Yangtze River with pink walls and tiles.

Under the guidance of traditional wisdom, the green transformation can not only meet the life pursuit of modern people, but also provide a more comfortable and healthy living environment for village residents. At the same time, it has reference significance for promoting the construction of local culture and rural revitalization and development in the new era.

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