

***Research on Evolution Mechanism and Development Strategy of Rural Human Settlement Environment Based on Characteristics of China-Suzhong Water Network— Taking Ping'an Community in Haimen City, Jiangsu Province as an Example***

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**Abstract**

The "frame-drainage-dike" water system in the rural areas of China's Suzhong is one of the achievements of the "Reclamation project" implemented by Zhang Jian in the early 20th century. On the one hand, the system has evolved into a unique geographical feature, which has important historical value. On the other hand, changes in lifestyles have impacted the human settlements in the area and the living mode adjacent to water makes water governance a problem of rural human settlements that has to be faced. Through the research on the evolution process of human settlements in this area, the water environment problem is the result of the comprehensive action of multiple factors which are as follows: 1. Pollution - the amount of pollution exceeds the self-cleaning load; 2. Structure - the network interoperability brings inefficiency of water pollution discharge; 3. Spatial pattern--village settlement planning changes the traditional human settlement pattern; 4. Life pattern--the dependence on the water system is reducing; 5. Pollution Control--the essence of government pollution control means is "governance after pollution first". The water pollution formation mechanism reflects the running-in process between the human settlement environment and the water system in the area, and its essence is the gradual deviation and passive treatment plan. Finally, in order to make full use of resource endowment and develop this water network system, this paper proposes strategies from the following aspects--the water, village and government. From then on, it improves the rural water environment governance system that adapts to new era.

Key words: rural areas in central Jiangsu, water network system, human settlements environment, evolution mechanism, comprehensive role, development strategy

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## 1. Introduction

As is known to all, Jiangnan Waterfront has been the leading role in the writings of writers since ancient times. For example, "一江烟水照晴岚，两岸人家接画檐，芰荷丛一段秋光淡";"君到姑苏见，人家尽枕河。古宫闲地少，水巷小桥多";"黄鹂巷口莺欲语，乌鹊河头冰欲销。绿浪东西南北水，红栏三百九十桥".They all express the water-town temperament of thin water and long flow, smoke and rain lanes in southern Jiangsu. But the plain area in central Jiangsu is also a water-town. What are its characteristics, how to integrate with the local human settlements model, what kind of environmental problems are faced, and how to protect and develop it?

Through the texture maps of 2 km<sup>2</sup> in the rural areas of southern and central Jiangsu, we can clearly see the difference between them. If the texture of rural areas in Suzhou is regarded as "perceptual nature", then the rural areas of Nantong City are "rational planning". Different from the characteristics of natural flow water network in southern Jiangsu, the water network in central Jiangsu often presents grid-like layout with strong artificial characteristics, which breeds different texture characteristics and residential patterns in rural areas of central Jiangsu, and has far-reaching significance for protection and development. However, with the passage of time, the gradual deterioration of water environment has become an urgent rural environmental problem to be solved in the context of the new era, and has become the key to Rural Revitalization and vitality remodeling.



Fig. 1 Texture Map of Rural Areas in Suzhou City, Jiangsu Province  
Source: Web search



Fig. 2 Texture Map of Rural Areas in Nantong City, Jiangsu Province  
Source: Web search

Taking the Ping'an community in Ruibei Village, Haimen City, Jiangsu Province, as an example, this paper combs the evolution process of human settlements under the water network system, traces back to the source and explores the water environment governance problems in rural areas in central Jiangsu Province, which is an important basis for the ecological civilization era to deal with the rural water environment governance and protect regional characteristics.

## 2. Human Settlement Model under the "Frame-drainage-dike" Water Network Structure

### 2.1 The plan for the purpose of “cultivating land and making money, expanding the people and expanding the industry”

Before reclamation, the central Jiangsu region suffered from frequent land salinization and river and sea disasters. Since the founding of Dasheng Yarn Mill, Zhang Jian found that people in the coastal areas of central Jiangsu, especially Haimen, were still suffering from natural disasters and no land. In 1885, Zhang Jian organized Tonghai Group Training, planned reclamation; in 1900, he formally took action, surveyed and mapped, and set up Tonghai Reclamation and Animal Husbandry Company (Fig. 3). The purpose of Tonghai Reclamation and Animal Husbandry Company was clearly stated in the Statute of Share Collection of Tonghai Reclamation and Animal Husbandry Company: "One thing is to make the land produce wealth, Qi people expand their business; the other is to increase the income of the country, and to make profits from capital and wealth...". By 1911, a total of 120,000 mu of land had been reclaimed. In 1914, Zhang Jian asked the court to open up state-owned wasteland for reclamation.

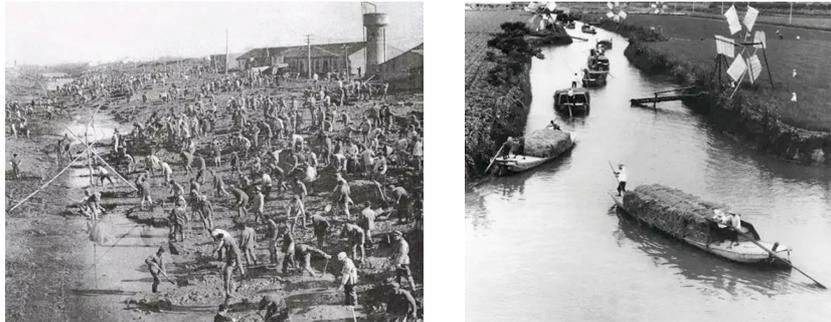


Fig.3 Reclamation Scene of Tonghai Project

Source: Web search

With the aim of “cultivating the land and making money, expanding the people and expanding the industry”, the plan is to lay the foundation for the establishment of the water network system in the Suzhong area. The water network system formed on this basis has changed the land salinization and the frequency of the rivers and seas in the coastal areas of the Soviet Union and China. The situation of the situation has formed a unique life pattern based on the water in the rural coastal areas .

### 2.2 The operation mechanism of water network guided by rationalism

The Tonghai Project shows that Zhang Jian is deeply influenced by pragmatic rationalism. When reclamation is carried out in this area, it first divides the area according to the local topographic and geomorphological characteristics, surveys and maps each area, and plans water conservancy according to local conditions; then it excavates the water system according to three levels, namely, the frame River (longitudinal), the drainage River (transverse), and the dike ditch (longitudinal), and sets up rivers in the backbone area between the area and the area, and the dike ditch on the south side of the central transverse road drains to it. A footbridge is built at both ends of each row of fields, crossing the Frame River to the main road. Unified grading standard for depth and width of gully and river, standard of straight grid of "井" type and chessboard type of road, and tillage and soil preparation (fig. 4).

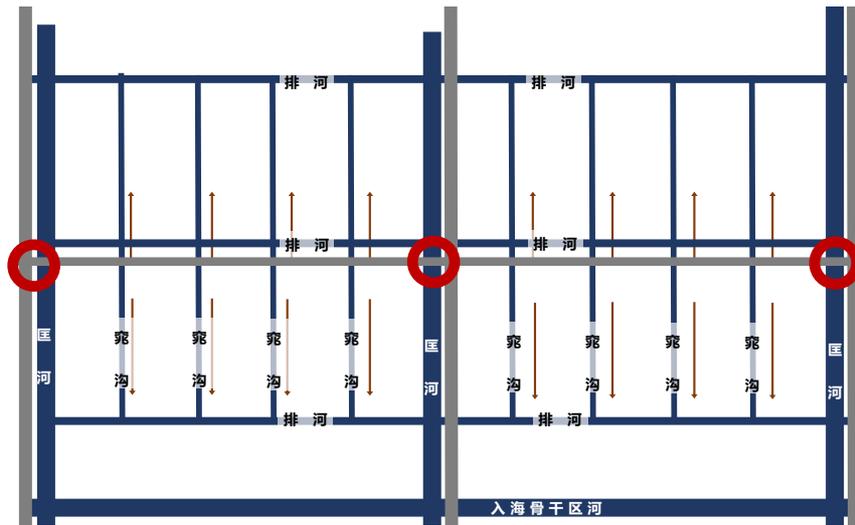


Fig.4 Water Network Model Diagram  
Source: Self-drawn by the author

### 2.3 Historical Humanistic Value in the New Era Background

The formation of the water network system has gradually enabled the local people to have jobs and settlements, and the development of the "frame-drainage-dike" water network system has a history of more than a hundred years. On the basis of the water network, a unique water-based life pattern has gradually formed in the rural areas of the Central Jiangsu Plain. Under the background of the new era, the landform signs of the original countryside have important historical and humanistic value and are worthy of protection and development.

## 3. Characteristics of human settlement patterns in the study area

### 3.1 Typical Village in Central Jiangsu

Haimen City is located in the southeast of Jiangsu Province, south of the Yangtze River. Because a large amount of sediment deposited in the Yangtze River Estuary to form sand bars, the basic scale of township land began to be established during Qianlong period. However, due to frequent floods along the Yangtze River, land reclamation is difficult and the development of towns and villages is hindered. At the beginning of the 20th century, Zhangjian organized to reclaim farmland and water conservancy, and gradually formed the embryonic form of farmland network. Since then, the water network has been closely related to people's lives.

This paper takes Ruibei Village Ping'an Community in Haimen City as an example, and chooses a range of about 1 km \*1 km to study (Fig. 5). The water system in the village is vertical and horizontal. Residences are arranged along both sides of the water system road, showing the typical spatial form of village in central Jiangsu Province.



Fig. 5 Scope of study  
Source: Self-drawn by the author

### 3.2 “Interlaced” Water system

In the research range of about 1km<sup>2</sup>, it includes the frame river at both ends of the east and west sections, with a width of about 2 meters and a distance of about 950 meters. The rivers at the north and south ends are about 1 meter wide and about 960 meters apart. The north-south gully has an average width of about 0.7-0.8 m and an average interval of about 12-15 m. Some local residents have self-extension water ponds, and their water nets basically have a grid layout and criss-crossing characteristics.

After the overall planning of the village in 1985, the main road of the east-west village was built, crossing the two sides of the frame river, cutting off the central gully, and the end between the local gully and the frame river was filled, showing the state of the broken river.

After calculation, the water network density in the study area is about 8.8km/km<sup>2</sup>, the water network layout is regular, the level is clear, and the mesh is intercommunicated. However, the problem of sulcus breakage is prominent (Fig. 6).



Fig. 6 An aerial photograph of the current situation of Ping'an community

Source: Photographed by the author

### 3.3 "Blue-green Mosaic" in Paddy Field

The study found that the farmland of the Ping'an Community in Ruibei Village was naturally divided by the water system, and the soil was localized and presented in a strip-like layout pattern. The layout was basically characterized by “the residential area is on both sides of the road and the farmland is at the ends” (Fig. 7). That is, the dwellings are concentrated on both sides of the main road in the central part of the country, and the farmland is concentrated in the development state of the north and south ends.

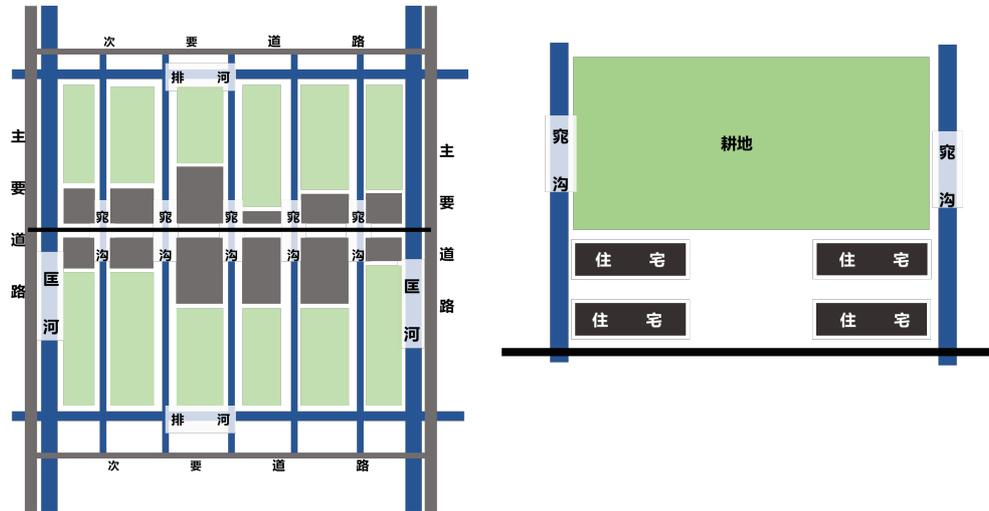


Fig.7 Layout pattern of farmland-dwelling-water system

Source: Self-drawn by the author

### 3.4 "Build by the Waterfront" of Residential Buildings

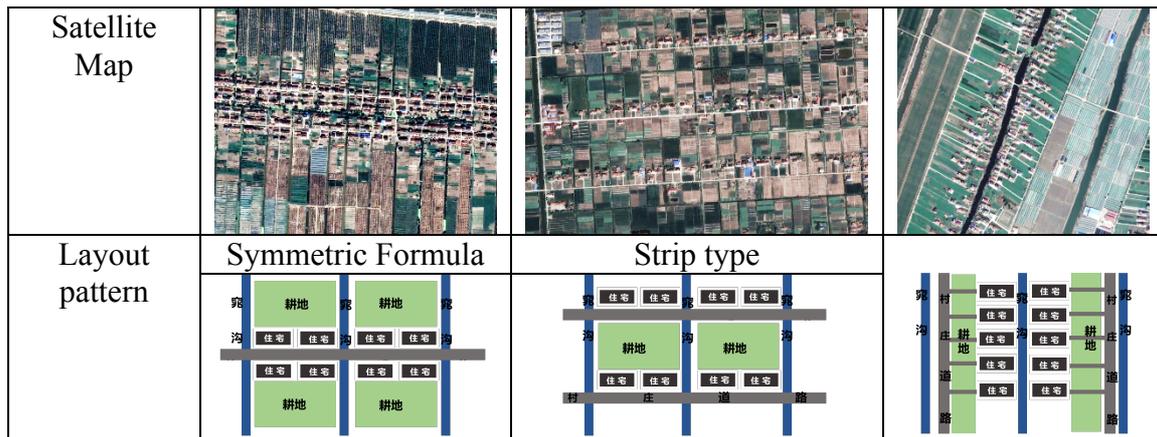
In the past typical research on the layout of rural areas in central Jiangsu, it was summarized as "high density strip type of coastal reclamation area". That is, the residential buildings located on both sides of rivers or roads show strip settlement distribution, or the rural space texture of "checkerboard grid" and so on.

On this basis, the author summarizes and refines it (Table 1). Firstly, according to the relationship between water system and road, it can be divided into two categories: parallel waterway and cross waterway. In parallel waterway, most of the dwellings are arranged along the canyon, while in cross waterway, most of the dwellings are arranged along the road and can be subdivided into arable land. - The "symmetry" of housing-road-residential-cultivated land and the "block" of housing-road-cultivated land.

Table 1 Classification Table of Residential Layout Patterns

Source: Self-drawn by the author

Relationship between water and roads	Crossing Water and Road: Arrangement of Residential Buildings along the Road	Water is parallel to road
Distribution of Residential Buildings	Arrangement along the road	Arrangement along the dike



The residential districts of Ping'an community show the characteristics of "building by water", which belongs to the "symmetrical" type of "crossing of waterways". The main roads of villages are vertical dikes, and the residential districts are mostly determinant layout. The overall layout of the residential districts shows scattered strips concentrated on both sides of the road. The inbound traffic connecting the main roads of villages in Ping'an community is built between the water system and the residential districts, separating the water system from the residents. The public space on one side of the river system is distributed in a narrow strip.

### 3.5 Difficulties in the management of sewage environment

With the continuous change of rural life mode, water environment problems become more and more prominent. Eutrophication of water body, waste dump by riverside, and direct drainage of rural domestic sewage, taking Ping'an community as an example, have become the water environment problems that plague the rural areas of the Central Jiangsu Plain (fig. 9). They have also become an important reason for the gradual alienation of local residential activities from water. In the face of "crisscrossing water systems" and "blue-green paddy fields". In the peaceful community of mosaic and residential buildings built by water, the deterioration of water environment and the living mode of water adjacent make water treatment become the problem of rural human settlements environment that we have to face.

## 4. Evolution Mechanism of Habitat Environment in Ping'an Community under the Characteristics of Water Network

### 4.1 Pollution - Pollution discharge exceeds self-net load of water system

The increase of pollution is the direct cause of the evolution of human settlements under the characteristics of the water network. In the early stage of water network formation, the rural ecological environment was good, the pollution discharge was less, and the water system could achieve self-purification. Since the 1960s, with the increase of pesticide and fertilizer consumption, the increase of industrial wastewater in the Yangtze Estuary and the continuous phenomenon that rural wastes and sewage were discharged directly into rivers without treatment, the discharge of rural pollution exceeded the negative effect of water self-purification. Lotus, leading to the gradual deterioration of the water environment.

In 2011, Nanjing promulgated relevant policies, the main rivers began to clean up water, but the water quality of dike ditch, which accounts for a large proportion of the

village, has not been improved.

Nowadays, there are four main pollution sources in Ping'an community, including industrial pollution, living pollution, agricultural pollution and aquaculture pollution. In the report, life pollution accounts for 50% of the total pollution, including domestic waste (plastic film, plastic foam, etc.) and domestic wastewater (organic matter, pathogens, eggs, etc.) entering the drainage system through direct drainage.

#### 4.2 Water network structure-network interchange brings low effluent discharge efficiency

The study found that the flow velocity of the water system in Ping'an community is low and almost zero. There are two reasons for this. First, the central Jiangsu area is flat, the water network belongs to the plain tidal river network, which forms the flow power through the upstream fluctuating tide. When the tide rises, the flow of frame river gains power through the upstream and then flows into the Drainage River and then into the canyon. The water speed is low. Secondly, the water network of "frame-drainage-canyon" structure has many intersecting joints because of its network interconnection, which further reduces the internal flow speed. In the case of high tide, the flow of Kuanghe River is from south to north, and the direction of flow into drainage and gully is uncertain (Fig. 8-9).

Moreover, the main road of the village built in 1985, which runs through the East and west, separates the North-South trench into a broken-head river. At this time, the Kuanghe River flows into the Drainage River and then into the trench. The direction of the flow is fixed, the direction of the Drainage River is uncertain, and the velocity of the internal flow is almost zero (Fig. 10). Through the author's field research and development, it is found that the pollution in the vicinity of the canal which is cut off by the main road in Ping'an community is particularly serious nowadays. Besides the phenomenon of domestic waste accumulation, there is also the drying up problem of the canal water system caused by long-term silt accumulation (Fig. 11).

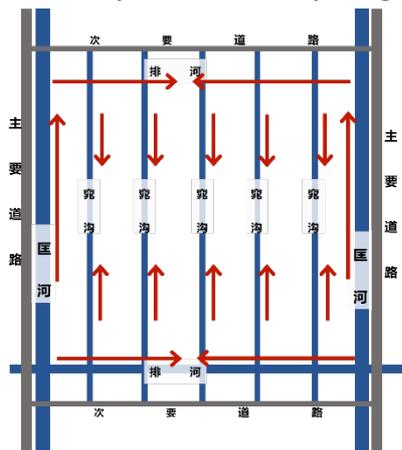


Fig. 8 Flow Direction before Main Road Construction (Taking Rising Tide as an Example)

Source: Self-drawn by the author

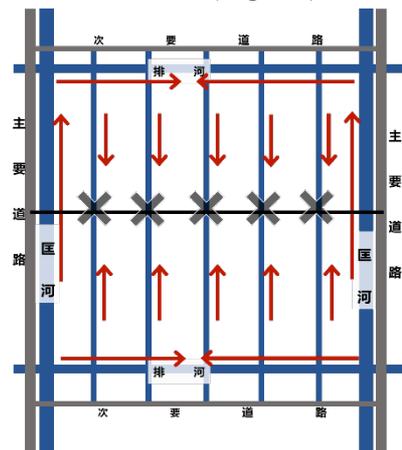


Fig. 9 Flow Direction after Main Road Construction (Taking Rising Tide as an Example)

Source: Self-drawn by the author

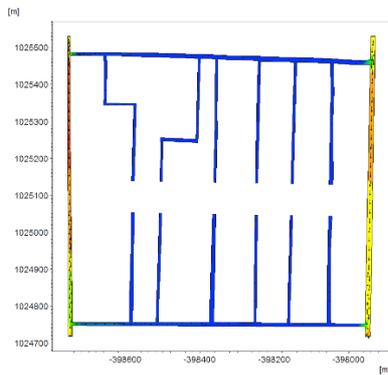


Fig.10 MIKE 11 software simulates water velocity

Source: Self-drawn by the author



Fig. 11 Status of pollution at the end of a dike

Source: Photographed by the author

### 4.3 Living Model: Decreased Dependence of Rural Living and Production on Water System

The change of life mode is directly reflected in the reduction of dependence on water system in rural production and life level, and the change of dependence on water system is also an important reason for the change of rural human settlements environment, mainly reflected in the change of rural life style, production mode and entertainment mode. First of all, in the agricultural era, the life style of living by rivers and drinking water has been changed. Now, with the popularization and development of tap water, the necessity of rivers for living has been replaced, and it is no longer an essential factor for survival. Secondly, in the aspect of production mode, the production of subsistence by farming is no longer cultivated because of the transfer of rural labor force to cities and the popularization of mechanized farming. Finally, in terms of entertainment mode, due to the rapid development of the modern information age, the entertainment mode of "water for pleasure" gradually disappeared, and the water bank as a rural public space was gradually replaced. On the one hand, the interaction between the changes of ecological environment on both sides of the water system and the changes of people's production and lifestyle, and the changes of production and lifestyle brought about water ring. The deterioration of the environment gradually leads to the combing of human settlements and water environment. On the other hand, with the completion of the new community center, rural residents advocate a preference for public open space with good hard pavement, in which the environment on both sides of the water system needs to be remedied.

### 4.4 Management System: The Overall Planning of Rural Residential Areas Reflects the Change of Human-Water Relation

The rural land system reform has brought about the transfer of rural living and production space, which has two main factors: passive system and active trend. Since Zhang Jian's implementation of reclamation and animal husbandry through the sea, the land management system in this area has undergone four stages of change. The first stage is the company tenancy system in late Qing Dynasty (1901). The head of household contracted land across the ditches and settled in scattered areas. The second stage is that after the implementation of land reform in 1949, the distribution of land among farmers gradually became average, basically one household, and initially formed a pattern of house-water-field. Residents settled in scattered areas of cultivated land with the ditches as the dividing line. Since the implementation of the household contract responsibility system in reform and opening-up, the rural

residential areas have been integrated, and the scattered residential layout has been integrated into a centralized determinant. Now with the large transfer of rural labor to cities, the cultivated land resources are gradually idle. Under the new era background, the trend of rural land cooperative scale operation has become more and more intense, and the government has re-integrated the existing land. Resources, centralized contracting and commissioned operation, belong to the active choice under the influence of the trend.

At the same time, the overall planning of rural settlements reflects the change of the relationship between people and water. In the early stage of the formation of water network, before the 1950s, the dwellings were semi-enclosed near the water, while new rural roads were built in the middle of communities, which formed the layout pattern of houses around the roads, farmland depending on both ends, the main roads of the countryside were separated from the ravines, and the direct connection between the dwellings and the water system was separated by inbound traffic. Therefore, the reform of land system and the overall rural planning have changed the production and living space and mode of traditional rural human settlements.

#### **4.5 Pollution Control - The essence of government's pollution control means is "pollution first, then treatment"**

From the point of view of water pollution control methods, rural sewage is directly discharged into the ditch, discharged into the Drainage River by the power of ebb tide, and finally into the frame river. However, the government's existing means of pollution control are often only to set up sewage treatment plants in the lower reaches of the frame river to treat rural sewage. Its essence is pollution first and then treatment.

In terms of internal river course cleaning, the government adopts physical methods to regularly clean up floating garbage in the river course. For the accumulated silt caused by rainstorm impact, the government first evaluates and classifies the quality of the canyon. For the canyon channel with better quality, the government will choose to dig out the silt and fill it in the canyon channel with poor quality, which results in the canyon. The length of the water system in the layer decreases, which impacts the structure of the water network.

### **5. Conclusion**

The water pollution formation mechanism reflects the running-in process of the human settlement environment and the water system in the area, and its essence is the gradual deviation and passive treatment plan of the rural production and living mode and the water network system. The reduction of dependence on the water system in the countryside and the low ability to control have formed the problem that the peaceful community is "not adjacent to water but not water, but does not see water". Therefore, in the context of the new era, facing the unique ecological and geographical features of the Soviet Union In the rural areas of China, the revitalization of water networks is not only related to restoring the ecological environment inside the village, but also has far-reaching significance for rural rejuvenation and vitality reshaping.

The water network in the rural areas of the Central Jiangsu Plain has distinct characteristics, which breeds a unique human settlements pattern, has profound epochal imprint and regional characteristics, records the development process of the region, and has far-reaching protection and development value. In order to protect and develop the water network system with distinct regional characteristics, the water network area in the Central Jiangsu Plain should make full use of its natural resources and bring into play the self-organizing benefits of rural space.

On the basis of these characteristics, this paper analyses the evolution mechanism of the local residential pattern, and finally puts forward some brief development countermeasures at the level of water network structure, villagers and government.

In the water network itself, it advocates opening source and activating network, improving the structure of water network, improving the operation efficiency of ecosystem, and forming a water network system of complex natural landscape and public activities. Through the planning and landscape design of linear rivers, the ecological riverside system adjacent to water is formed by connecting lines. At the same time, parks can be set up at the intersection of the main and secondary rivers as amplification nodes of the linear system of villages, carrying public activities of the whole rural community.

At the villagers' level, they advocate autonomy and sharing, improve the enthusiasm of improving the water environment in their hometown, take self-improvement and management as the goal, reduce spontaneously and break the water system.

Finally, the government needs to improve the rural sewage and rainwater diversion system, treat the sewage problem from the root, and guide the rural residents organically, in order to control the upstream industrial pollution emissions, add garbage collection stations in rural areas and other ways to reduce the emissions of pollution sources.

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