Research on spatial characteristics and planning patterns of settlements in the Jingjiang River Flood Diversion Area, China

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Abstract

In the context of the shortage of land resources in China, there are some human settlements built in the flood diversion areas. These settlements were planned and constructed in conjunction with water conservancy projects arranged by the state, and assume the function of resettlement and flood control. Taking Jingjiang River Flood Diversion Area, an important large-scale water conservancy project constructed in China's Changjiang River Basin in the 1950s, as the research area, this study aims to reveal the planning pattern of the settlement spaces built in this special area in the early period of New China. In this article, the development of its hydraulic environment and human settlements is sorted out. Based on this, the location, scale, form and layout of the 19 refuge areas are analysed, and their formation logic is explored. The results show that the refuge areas in the Jingjiang River Flood Diversion Area have developed unique spatial characteristics driven by flood diversion, resettlement and agricultural production needs. Their physical space is closely related to the water conservancy facilities, developing a specific pattern highly adapted to flood diversion, which has the effect of improving the security of residents' life and production, and reflects the planning ideas of "coexisting with the water and integrating as a whole". The research findings contribute to the recognition of the value characteristics of settlements in flood diversion areas, and provide a reference for the understanding of the national governance during the early period of New China.

Keywords
New China period; flood diversion areas; settlements; spatial characteristics; planning ideas

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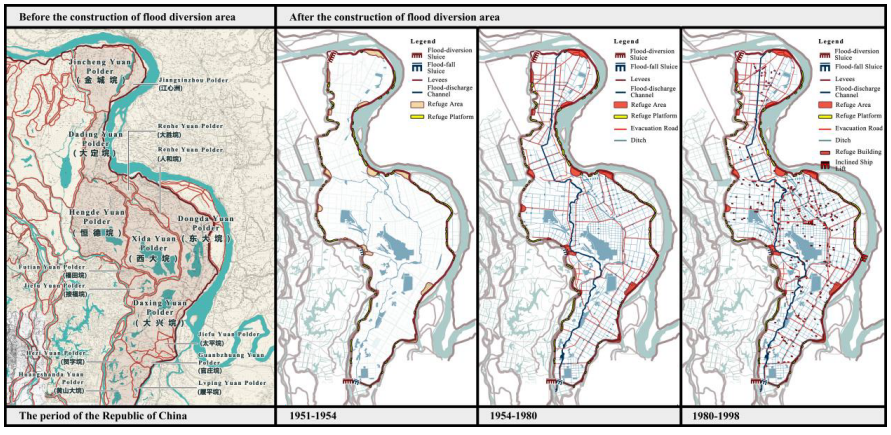


Fig. 1. Development process of the hydraulic environment and human settlements in the Jingjiang River Flood Diversion Area during the 20th century. The second half of the 20th century was a stage of the development and refinement of the human settlement system in the flood diversion area.

INTRODUCTION

There exists a special type of human settlement in the flood diversion areas of China's major rivers. They were planned and constructed in conjunction with water conservancy projects arranged by the state under the socialist system. These settlements present specific spatial patterns due to their function of resettlement and flood control. The Jingjiang Flood Diversion Area, established in Changjiang River Basin of China in the 1950s as the first large- scale water conservancy project after the founding of the People's Republic China, is chosen as the subject of this study because of its significance and representativeness.

In the early years of New China, the state made great efforts to construct flood diversion areas in the middle and lower reaches of major river basins to address water disaster issues. Before the founding of New China, long-term uncontrolled reclamation and internal and external problems led to the stagnation of the flood control construction. For example, the embankments on the banks of the Jingjiang River section of the Changjiang River were breached in 28 years between 1912 and 1949.[1] The frequent floods posed a significant threat to the normal life of the general public along the rivers. In this context, the Chinese government placed great emphasis on water management, considering it an urgent task to restore the national economy and protect the lives and property of the people, and has led the people to carry out large-scale water conservancy construction throughout the country. Jingjiang River, being one of the most challenging areas for water management in China, had thus become a critical focus for flood control along the Changjiang River. The Changjiang River Conservancy Commission submitted the "Jingjiang Flood Diversion Project Plan" to the national government in 1950, and it was approved by Chairman Mao Zedong.[2] The main construction of the project was completed in 1952.[3] Today, it is situated in Gong'an County, Hubei Province.

The refuge area project is an essential component of flood diversion area construction, designed to safeguard the people's living conditions. The Jingjiang Flood Diversion Area implemented a resettlement strategy primarily focused on relocating residents. Within the flood diversion area, there were originally 240,000 residents. 20 refuge areas protected by embankments were planned and constructed by national investment based on the opinions of local governments and the public from 1952 to 1953. [4] The Jingjiang Flood Diversion Resettlement Commission resettled 160,000 people in these areas. [5]Subsequently, the number of refuge areas in the flood diversion area has stabilised at 19 after being abolished, merged and newly built, with a population of 180,000 residents.

The state requires all levels of government to provide necessary guidance and assistance in the safety and construction of flood diversion areas to rationally and effectively utilize the flood diversion area and to adapt the life and economic activities of their inhabitants to the requirements of flood prevention. [6]As a result, the settlements in flood diversion areas have a distinctly top-down development approach and are related to hydraulic engineering projects. However, there is currently scarce research on the human settlements under the impact of hydraulic construction in this region. Therefore, this study aims to reveal the planning patterns of these human settlements formed in this special area during the early period of the People's Republic of China by analysing their spatial characteristics and discussing their formation logic. In this paper, we review the changes in regional hydraulic environments, identify the constituent elements and settlement types of the Jingjiang Flood Diversion Area. Based on this, we analyse the location, scale, form, and layout of the 19 refuge areas (the primary settlement types), discuss the relationship between human settlements and hydraulic engineering projects, and explore the inherent wisdom in human settlement construction.

DEVELOPMENT OF THE HYDRAULIC ENVIRONMENT AND HUMAN SETTLEMENTS IN THE JINGJIANG RIVER FLOOD DIVERSION AREA

Due to the threat of flooding, water conservancy construction has become the key to the development of the Jianghan Plain region. During the Ming and Qing dynasties, the people of the Jianghan Plain gradually established a "hydraulic society" based on collaborative assistance through a series of water management activities such as embankment construction, maintenance, and management.[7] At the same time, the hydraulic engineering elements physically influenced settlement spaces. The hydraulic environment and human settlements in the Jingjiang Flood Diversion Area underwent the following development in the 20th century (Figure 1).

1912-1949: Frequent floods occurred in the Changjiang River basin during the Republic of China period. Due to the lack of organized water management, river channels, islands, and lakes were blindly reclaimed for agriculture, exacerbating conflicts between people and water over land. At that time, flood prevention mainly relied on embankment construction, and the enclosed spaces formed by embankments were called "polder" (yuan 垸), which were used to

safeguard production and living spaces. Different polders were interconnected by embankments, and a self-contained system was formed in each polder. Residents built settlements based on family units, relying on natural or artificial highlands, resulting in dispersed settlements.[8] As populations and housing increased, many settlements merged. Moreover, residents along the riversides developed towns at the intersections of embankments and rivers or at the harbours along the rivers, relying on the flood control conditions and water transportation advantages. Taking high grounds, constructing embankments, and enclosing fields have become the basic strategies for subsequent flood diversion area construction. Although traditional polders once met the needs for production and disaster avoidance, the lack of unified management at that time only allowed for small-scale flood regulation, providing limited security for settlements.

1951-1954: After the construction of the Jingjiang River Flood Diversion Area, the layout of the embankment was reorganised, refuge areas and refuge platforms were initially constructed, and the original settlement pattern was altered. In order to ensure the safety of the residents in the diversion area, as well as to provide a level floodway during flood diversion, all dilapidated embankments and piers were levelled. The polders were combined into one big area, which is surrounded by Jingnan dike, Hudong dike and Nanxian dike into a circle with a length of more than 210km, with a total area of 921.34km^2. Refuge areas and refuge platforms for resettlement were constructed by the state through unified organisational planning. The refuge area is a technical term in the hydraulic engineering, referring to the independent enclosure built by using the flood diversion area's embankments. It serves as the town for the residents of the flood diversion area to live, and is used to isolate the flood water and temporarily resettle the people who usually live outside when the floods occur. The refuge platform refers to the temporary shelter used for moving residence in case of flood diversion, which is built on top of an earthen platform above the design water level along the embankments. [9]

1954-1980: Towns within the embankment were gradually expanding and the evacuation and transferring road network is being supplemented. With the support of the local brick and tile industry and State funding, the people in the hinterland of the flood diversion area have built 950 brick resettlement houses with sloped roofs on the basis of 15 square metres for each household[10] and 85 flood warehouses[11] in the refuge areas and refuge platforms. The resettlement houses were built by the Jingjiang Floodplain Construction Command, a specialised construction unit for the flood diversion area. Their property rights and management are entrusted to the people's communes and production units, which allocate them to the families normally living in the hinterland. At the same time, in order to cooperate with the river network movements, the canals were dug and the roads were piled up in the hinterland of the flood diversion area, forming a network of orthogonal roads adjacent to the irrigation canal system, with intervals of 400-600 metres.[12] Relying on the transferring road network, the people in the hinterland have formed an internal transfer and resettlement pattern of "settling and farming in the countryside during normal times and moving to the towns to avoid disasters during floods". The towns in the refuge areas were constantly being expanded inside the embankment, and have developed into modern towns with a range of industrial, residential, consumer and public service functions.

1980-1998: The resettlement system has been further improved, forming a system composed of refuge areas, refuge platforms, refuge buildings, and transferring roads and bridges. In 1982, the Hubei Provincial Water Resources Department approved the construction of refuge buildings in the hinterland of the flood diversion area, and by 1992, a total of 246 refuge buildings had been built for residents who were inconvenient to move. In 1990- 1992, a new boat hoist was built in Huangshuitao Refuge Area, which was used as a transport hub for conveying life-saving boats after the flood diversion, transferring people and materials from refuge buildings and for external contact.[13] At the same time, the transferring road, bridge and the ferry along the river were improved to strengthen the transfer and resettlement capacity. By the end of the 20th century, a multi-functional system integrating flood control, resettlement and agricultural production was formed in the Jingjiang Flood Diversion Area.

SPATIAL CHARACTERISTICS OF THE REFUGE AREAS

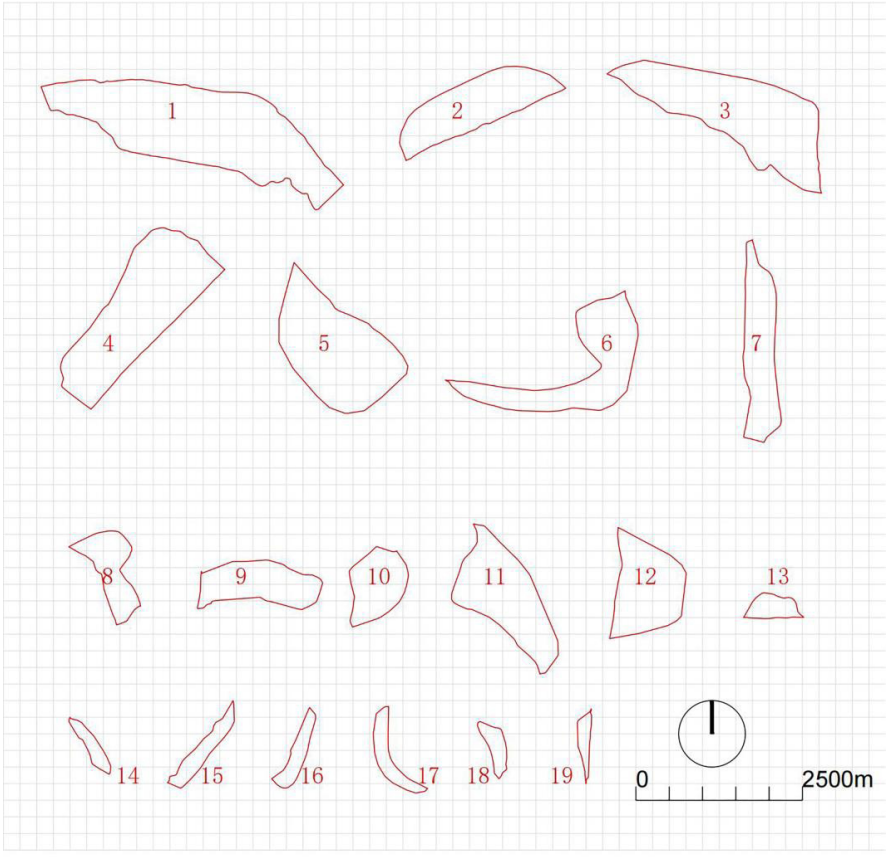
As a significant outcome of the resettlement project, the refuge areas have become the primary settlement space within the flood diversion area. The location, scale, form, and layout of these settlements are closely related to the water conservancy facilities.

Location: The refuge areas were constructed relying on river dikes and embankments, interconnected by enclosing dikes, presenting a relatively even distribution along the river dikes. Their location must ensure the normal operation of flood diversion and agricultural production. From the perspective of flood diversion, the ground within the flood detention and retarding area needs to remain level, so the main flow area should be free of houses, earthworks, and other obstacles that hinder the flow of floodwaters. Therefore, settlements should ideally be concentrated at the edges of the flood detention and retarding area. However, from the agricultural production standpoint, the farmland and water conservancy facilities in the centre of the flood detention and retarding area need frequent maintenance, which means it inconvenient for farmers to live far from their fields. Under these conditions, the state, giving priority to flood safety while considering a reasonable distance to the agricultural land, has selected the location of refuge areas along the main dikes of the flood diversion area at intervals of 5-10 km, ensuring that the distance from the refuge areas to the fields does not exceed 3-5 km. [14] Among these refuge areas, two-thirds were constructed by relying on existing settlements. Some of them were built based on the existing towns established during the Republic of China era, which were often located near rivers and dikes, benefiting from transportation locations. After the founding of the People's Republic of China, the spatial layout of these towns was preserved, and new spaces were created around them for the construction of roads and resettlement housing. Embankments were built around the towns to form enclosed refuge areas. The others were developed from civilian polder villages of the Republic of China era. The original village mounds within the embankments were removed, and several civilian embankments were merged to form a new refuge area. The remaining one- third were constructed in a new location along river dikes (Table 1).

Refuge area	Foundation	Location	Relationship with river	Area (km²)
Buhe (埠河)	Rely on existing towns	Northern part	Along Jingjiang River	4.09
Yugongyuan (裕公垸)	Rely on existing villages	Southern part	Along Jingjiang River	2.78
Yangjiachang (杨家厂)	Rely on existing towns	Northern part	Along Jingjiang River	2.67
Douhudi (斗湖堤)	Rely on existing towns	Northern part	Along Jingjiang River	2.34
Ouchi - Nijiata (藕池-倪家塔)	Rely on existing towns	Southern part	Along Jingjiang River	1.705
Huangjinkou (黄金口)	Rely on existing towns	Northern part	Along Hudu River	1.60
Leizhou (雷洲)	Rely on existing villages	Northern part	Along Jingjiang River	1.51
Jiazhuyuan (夹竹园)	Rely on existing towns	Northern part	Along Hudu River	1.27
Yiheyuan (义和垸)	In a new location	Northern part	Along Hudu River	1.24
Donggangzi - Wudahe (东港子-吴达河)	Rely on existing towns	Southern part	Along Hudu River	0.96
Shuiyue (水月)	Rely on existing villages	Northern part	Along Hudu River	0.72
Zhakou (闸口)	Rely on existing towns	Southern part	Along Hudu River	0.64
Guojiaxiaoyuan (吴家小垸)	In a new location	Southern part	Along Hudu River	0.30
Shaojiagang (邵家岗)	Rely on existing villages	Southern part	Along Jingjiang River	0.29
Bajiapu (八家铺)	In a new location	Southern part	Along Jingjiang River	0.25
Baohengyuan (保恒垸)	In a new location	Southern part	Along Hudu River	0.23
Xinkou (新口)	In a new location	Southern part	Along Hudu River	0.18
Huangshuitao (黄水套)	Rely on existing villages	Southern part	Along Jingjiang River	0.16
Yanglinsi (杨林寺)	In a new location	Southern part	Along Jingjiang River	0.14

Table 1. The information of the refuge area settlements.

Scale: The overall area of the refuge areas is constrained by flood diversion requirements. According to the design specifications for flood detention and retarding basins, the area allocated for refuge construction should not exceed 5% of the flood detention and retarding volume. The total area of the 19 refuge areas in the Jingjiang River flood diversion area is 23 km², accounting for 2.5% of the flood diversion area. The sizes of individual refuge areas range from 0.14 to 4.00 km²(Figure 2). Nearly half (9) of them are larger than 1 km². Among them, 89% (8) are developed on original sites, 78% (7) are located in the generally higher terrain of the northern half, and 67% (6) are situated on the side of the Jingjiang River. Additionally, there are 7 refuge areas with sizes less than 0.3 km², which are generally located in the lower-



1.Buhe（埠河）, 2.Leizhou（雷洲）, 3.Yangjiachang（杨家厂）, 4.Yugongyuan（裕公垸）,
5.Douhudi（斗湖堤）, 6.Ouchi - Nijiata（藕池–倪家塔）, 7.Yiheyuan（义和垸）, 8.Zhakou（闸口）,
9.Wudahe - Donggangzi（吴达河－东港子）, 10.Shuiyue（水月）, 11.Huangjinkou（黄金口）,
12.Jiazhuyuan（夹竹园）, 13.Baohengyuan（保恒院）, 14.Huangshuitao（黄水套）, 15.Shaojiagang（邵家岗）,
16.Bajiapu（八家铺）, 17.Guojiaxiaoyuan（吊家小垸）, 18.Xinkou（新口）, 19.Yanglinsi（杨林寺）

Fig. 2. Scale. The size of a single refuge area varies from 0.14 to 4.00km^2, depending on the design specifications of the flood detention and retarding area and the spatial conditions of the base sites.

lying southern half of the flood diversion area and are often rebuilt in new locations. The results indicate that the size of the refuge areas is related to the construction foundation and correlates with the drainage capacity of their terrain. On one hand, original sites have withstood historical challenges, offering higher safety. Additionally, developing refuge areas based on original sites allows for the direct use of accumulated population, transportation, and land resources, benefiting urban development. Therefore, refuge areas developed on original sites tend to be larger, while newly built refuge areas are often smaller. On the other hand, due to terrain differences, the lower-lying southern part is more prone to deeper and longer-lasting water accumulation, making it relatively more dangerous. Consequently, refuge areas in the

southern part are generally smaller, while most larger refuge areas are located in the northern half. Thus, the total area of refuge areas is limited, and the scale of specific refuge area is influenced by safety considerations and development potential.

Form: The spatial form of the refuge areas needs to be adapted to withstand flooding. Each refuge area is enclosed by embankments, with one side bordered by the main dike of the flood diversion area. The main dike is classified as a secondary dam, while the other enclosing embankments are classified as tertiary dams. They rise 9-13 meters above the surrounding ground, have a crest width of 6 meters, and slopes with a gradient of 1:3 on both sides, covered with grass. In terms of shape, the refuge areas are generally elongated along the direction of the main dike. This design maximizes the use of the main dike and minimizes the construction effort. In order to resist the impact of water flow during the flood diversion period, the corner of the embankments is rounded, and the protection forest is built at the foot of the embankments facing the water. The enclosing dikes and embankments establish the development boundaries for the towns at that time.

Layout: In addition to general urban development, flood control and temporary resettlement are comprehensively considered in the land use layout of refuge areas. This paper analyses the layout characteristics of the built-up situation within the 1970s' refuge area (Figure 3). Within the refuge area there are disaster response systems, drainage systems, transport systems, as well as conventional residential, commercial, and industrial zones. (1) The disaster response system mainly includes dikes, sluices, temporary resettlement housing, and flood control material warehouses. During flood diversion, when the water level outside the area is higher than inside, the sluice gates must remain closed. The resettlement houses are row-style collective residences, with each building capable of accommodating 6-20 households. Each household is allotted 15 square meters. [15]There is a space of eight meters in the front and six meters in the back of each house to ensure smooth passage for resettlement vehicles. [16] These resettlement houses are constructed parallel to the roads. Flood control material warehouses are located near the embankments and store emergency facilities such as gravel, sand, woven bags, life jackets, etc., in accordance with the flood control contingency plans for the watershed. These buildings are subordinate to and serve the flood control emergency plans of the flood diversion areas, ensuring the normal operation of the refuge area. (2) The drainage system mainly consists of sluice gates, drainage channels, and drainage culverts. Gates are installed at the intersections of rivers and embankments. Drainage channels are often open channels with a width of 4-6 meters, traversing the central part of the refuge area or encircling along the boundaries. Drainage culverts, as a type of pipe structure, effectively guide water flow. (3) The transportation system mainly consists of the terrestrial road network. The layout of the roads follows the original embankments and field ridges. The roads show the traditional characteristics of being built on embankments or along the water in their names, such as "Hengdi" (Transverse Embankment) Road, "Youjianghe" (Youjiang River) Road, and "Jingjianghe" (Jingjiang River) Road. The road network connects outward with ports along the river and inward with resettlement roads leading to the hinterland. Some refuge areas feature irregular grid-shaped road layouts, while other refuge areas have road networks characterized by a fishbone-shaped structure, with roads mainly running parallel to the main dike. The roads form the spatial framework of the refuge area, connecting scattered resettlement housing areas.

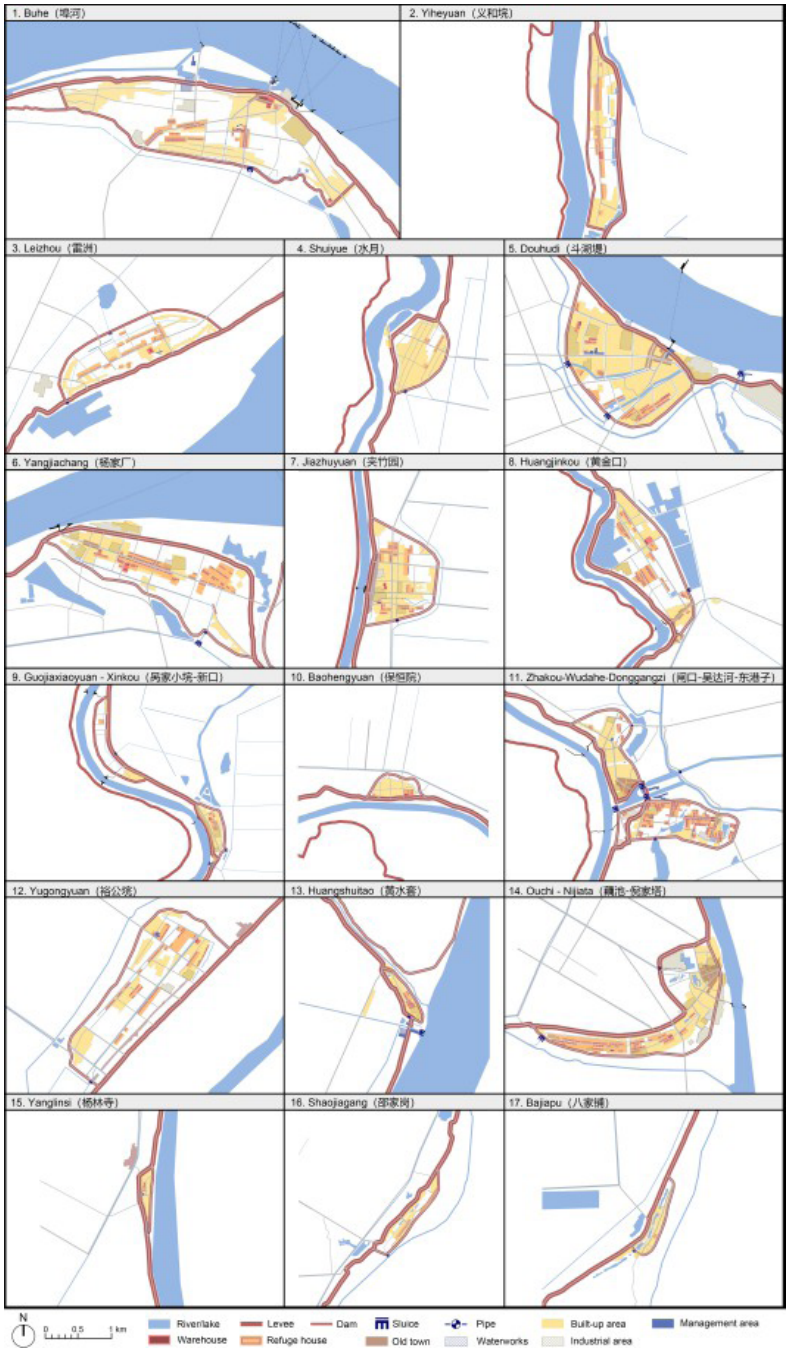


Fig. 3. Spatial form and layout of the refuge areas in the 1970s. The long axis of the refuge settlements generally conforms to the main levees, and the corners are rounded at the turning point. The settlements contain disaster response systems, drainage systems, and transportation systems to meet flood control needs, as well as conventional urban land.

Other construction land is then developed within the dikes based on this framework. The disaster response system, drainage system, transportation system, and urban development land in the refuge area are coordinated with each other, forming the characteristic layout.

PLANNING PATTERNS OF THE REFUGE AREAS

According to the governance policy of "focusing on flood diversion, ensuring safety during flood diversion, and ensuring harvests during normal times", [17] the construction of the Jing River flood diversion area and its refuge settlements has reflected the planning patterns with far-sighted ideas and effective strategies at macro and micro levels.

The overall distribution of refuge areas in the flood diversion area reflects the planning ideas of comprehensive coordination and multifunctionality at the macro level. To more effectively address flood issues, the planning perspective was extended to a wider scope than that of individual settlements, and a large-scale centralised flood- control zone was creatively built, with systematic dike and embankment construction. On this basis, taking into account the scarcity of national land resources, flood control was not separated from people's livelihoods and agricultural production. Instead, through the construction of resettlement systems and agricultural irrigation systems, proper arrangements are made for the people's lives and property security. The planning and construction of settlements in the flood diversion area comprehensively coordinate multiple demands including flood diversion, residential safety, and agricultural production, forming a nested spatial pattern of rivers and dikes, refuge areas, and flood detention and retarding basin (agricultural hinterland). The refuge area settlements are evenly distributed along the edges of the flood diversion area, striking a balance between meeting the needs of flood control during disasters and facilitating production. The refuge areas and other relocation facilities, including refuge platforms and refuge buildings for temporary shelter, as well as transferring roads and bridges for evacuation, together constitute a complete resettlement system. Along with the agricultural production system, they form a unique living and production system in the flood diversion area (Figure 4).

The spatial construction of refuge area settlements reflects the planning ideas of balancing normalcy and disaster preparedness, and coexisting with water at the micro level. The location, scale, form, and layout of the refuge areas

are closely combined with water conservancy facilities, forming highly flood-adaptive "water conservancy settlements". A series of strategies were developed for their construction. (1) Flood Isolation: Utilizing dikes and sluice gates to keep floodwaters out of the refuge areas during flood diversion. The location of the main dike within the flood diversion area limits the range of possible sites for refuge areas, while the surrounding embankments further delineate the boundaries of these settlements. (2) Internal Flooding Solution: Constructing drainage systems to address the issue of poor drainage within embankment-enclosed settlements. (3) Scale Control: Keeping the total size of the settlements within certain limits according to flood diversion requirements, and determining the size of individual settlements based on

safety risks and development potential. (4) Disaster Preparedness: Prioritizing the construction of temporary resettlement housing, warehouses, and other disaster response facilities as key projects in town development. These are connected to external evacuation and transferring roads via main town roads. (5) Maintaining Connectivity: Developing a clear and simple road network that connects to river ports on one side and to transferring roads leading to the hinterland on the other. During normal times, these roads serve as economic lifelines for the towns, and during disasters, they become vital evacuation routes.

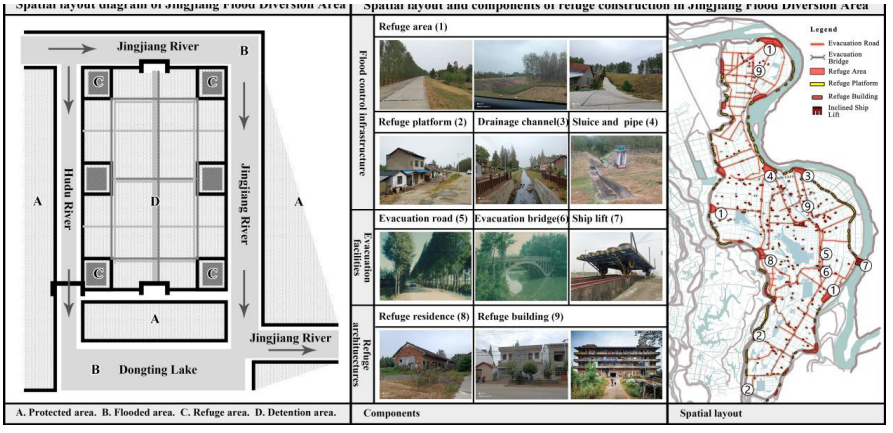


Fig. 4. Resettlement system with the refuge area as the major component. Together with other flood diversion and relocation facilities such as refuge platforms, shelters, evacuation roads and bridges, as well as agricultural production facilities, the refuge areas constitute a holistic living space system.

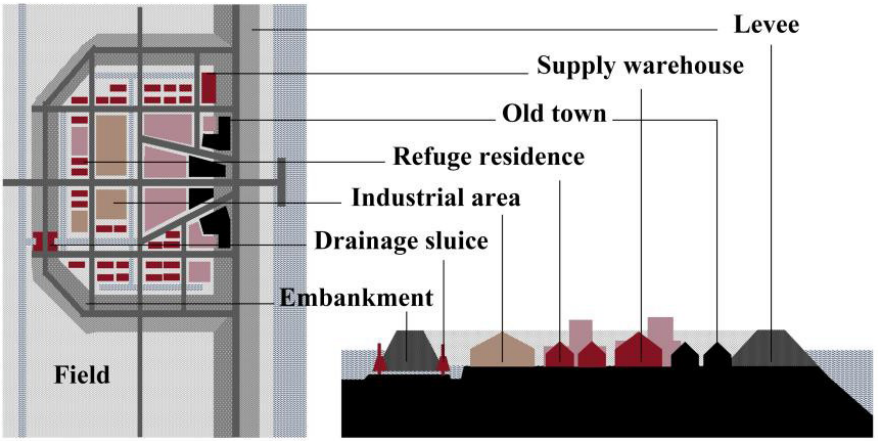


Fig. 5. Spatial pattern of the refuge areas. The hydraulic facilities such as embankments, drainage culverts and gates, resettlement houses, warehouses for flood defence constitute the characteristic elements of the refuge area.

CONCLUSION

This study focuses on the refuge areas established with the national water conservancy project of Jingjiang River Flood Diversion Area, and examines the formation process and spatial characteristics of these special settlements in the second half of the 20th century. It is found that the refuge areas have commonalities with general settlements and also form unique spatial characteristics under the influence of the special environment. As an important part of the flood diversion area, they need to be built with simultaneous consideration of flood diversion, temporary resettlement and agriculture production. The 19 refuge areas, in collaboration with other resettlement facilities (refuge platforms and buildings, evacuation roads and bridges), and in coordination with the agricultural hinterland, together constitute a unique human settlement spatial system in the flood diversion area, which has the effect of improving the safety and security of residents' life and production, and reflects a holistic planning approach. Moreover, the space of these 19 refuge areas is highly adapted to the flood diversion function, featuring elements such as enclosed dikes and embankments, drainage facilities, disaster response facilities, which form a distinctive physical space reflecting the efforts to cope with floods.

The refuge area settlements reflect the national intention of regional governance and the systematic planning thinking. We can draw planning wisdom for water management and settlement from the earlier planning approaches. In regional planning, appropriately allocating land for flood can enhance overall disaster prevention capabilities. In urban planning, developing a spatial system that is comprehensively adapted to the needs of flood control can contribute to the resilience of the living space. The engineering wisdom of integrating as a whole and the ecological wisdom of coexisting with the water still hold significant relevance in the face of the current climate emergency.

As a result of national water control and local development, the refuge area settlements are not only historical witnesses to New China's achievement of governance, but also memory carriers of local residents' collective disaster resilience and living experience, as well as typical embodiments of the planning ideas with the characteristics of the times. These settlements in the Jingjiang River Flood Diversion Area have important historical and cultural value, and their conservation and development deserve further study and consideration.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

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IMAGE SOURCES

Figure 1 The author. (The first from left is drawn by the author based on the 1: 10,000 Topographic Map of Hubei Province. Survey Bureau of the Ministry of National Defence, Republic of China [1926]).
Figure 2 The author.
Figure 3 Drawn by the author form the Planning Map of Refuge Areas. Jingjiang River Flood Diversion Area Administration of Hubei Province [1970s].
Figure 4 The author.
Figure 5 The author.

ENDNOTES

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3. Xinhua News Agency, "Jingjiang Fenhong Gongcheng Jijiang Quanli Shigong."

4. Changjiang Water Resources Commission, *Jingjaing Fenhong Gongcheng Jishu Dheji Caoan*, 29-30.
5. Peng and Hu, *Jingjiang Fenhong Gongcheng Zhi (Chugao)*, 108-110.
6. The State Council, *Xuzhihongqu Anquan Yu Jianshe Zhidao Gangya*o.
7. Lu, "The Making of Water Community."
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11. Codification Committee of "Gong'an Xian Zhi", *Gong'an Xian Zhi*, 121-122.
12. Wang and Qu, "Hewanghua."
13. Yangtze River Administration of Jingzhou, *Jingjiang Difang Zhi*, 419.
14. General Institute of Water Conservancy and Hunan Water Conservancy, *Xuzhihongqu Sheji Guifan*.
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16. Peng and Hu, *Jingjiang Fenhong Gongcheng Zhi (Chugao)*, 302.
17. Peng and Hu, *Jingjiang Fenhong Gongcheng Zhi (Chugao)*, 3.