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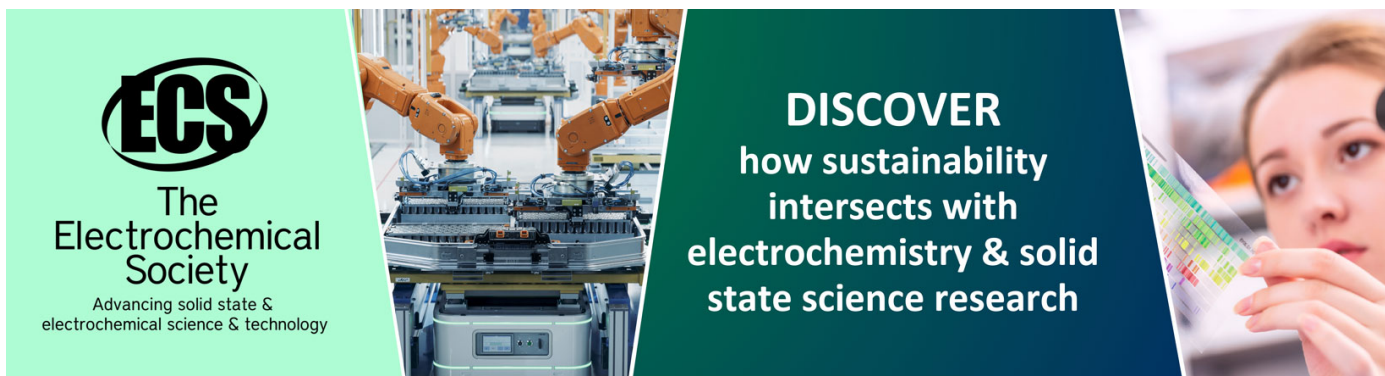
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Study on the evaluation and optimization of ecological spatial layout of the lower Yellow River floodplain

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Abstract. There are some problems such as insufficient ecological space in the floodplain of the lower Yellow River. Based on the analysis of the function orientation of the floodplain, this paper constructs the comprehensive evaluation index matrix of the ecological spatial layout. Taking the floodplain of the plain demonstration area as a typical example, the regional flood control safety conditions, agricultural development conditions, socioeconomic conditions, and river ecological conditions are comprehensively evaluated. Based on the comprehensive analysis of the key conditions of town, agriculture, and ecology, the suitable areas for town construction, agricultural production, and ecological protection are defined respectively. Combined with the flood control safety requirements of the floodplain, the ecological space layout of the floodplain is optimized to propose the Yellow River new ideas for the optimization of the ecological spatial pattern of the downstream floodplain.

1. Introduction

The floodplain of the lower Yellow River is 3154 km², accounting for 65% of the river channel area, there are more than 3.4 million mu of cultivated land in the floodplain, with a population of 1.9 million. The downstream floodplain is not only the place where the Yellow River flows through the flood, holds back flood and settles sand, but also the home for the people in the beach to survive, and the unique ecological space of the North China Plain.

In terms of its ecological function, the floodplain in Henan Province is an important part of the "four areas - three belts" regional ecological security strategic pattern - "Yellow River floodplain ecological conservation belt", and an important ecological security barrier of "plain ecological conservation area" in Henan Province. The floodplain in Shandong Province is an important part of the "two screens, three belts, and four areas" regional ecological security strategic pattern - "along the Yellow River protection zone", and an important framework of the regional ecological barrier in Shandong Province. At present, there are two national and three provincial nature reserves in the lower reaches of the Yellow River, and the floodplain has unique natural ecological resources. There are more than 30 large and medium-sized cities such as Zhengzhou and Jinan on both sides of the river, with a population of more than 50 million, the urban ecological space is scarce, and there is an urgent need to get close to the Yellow River. Therefore, it is necessary to carry out a comprehensive assessment and optimization of the ecological spatial layout of the floodplain of the lower Yellow River.



Taking the typical area in the lower Yellow River floodplain as the research object, this paper constructs the evaluation index matrix of ecological spatial layout, evaluates from two aspects of basic conditions and the suitability of ecological spatial development, and optimizes the ecological spatial layout according to the evaluation results.

2. Materials and methods

2.1. Evaluation Index

According to the functional orientation and intra-regional scale differences of the floodplain in the lower Yellow River, from the aspects of flood control security, socio-economic development, and ecological protection functions, the evaluation factor indexes are selected and the comprehensive evaluation index matrix of spatial layout based on the functions of the floodplain is constructed, as shown in Table 1.

Table 1. Comprehensive evaluation index system of functional spatial layout of the floodplain in the lower Yellow River

		Flood control safety conditions	Conditions for agricultural development	Socioeconomic conditions	River ecological conditions
Suitable area	Urban construction area	Elevation Flood threat distance from safe evacuation	--	Economic radiation distance Water supply convenience Transportation convenience Public facilities convenience Current construction land distribution	--
	Agricultural production area	Elevation Slope flood threat distance	Slope water resources abundance Irrigation convenience Distribution of current agricultural land	--	--
	Ecological reserve	--	--	--	River range Scope of current water area distribution protection area

The evaluation of basic conditions mainly includes four aspects: flood control safety conditions, agricultural development conditions, socioeconomic conditions and river ecological conditions. Among them, the evaluation of flood control safety conditions includes four indexes: elevation and slope reflect the risk degree of flood threat; the flood threat distance is the distance from the main channel of the Yellow River, reflecting the risk of inundation in case of flood disaster; the safe evacuation distance is the distance from the Yellow River levee, reflecting the evacuation difficulty of people and property in case of flood disaster. The evaluation of agricultural development conditions

includes four indexes: the slope reflects the convenience of agricultural cultivation in each region; the abundance of water resources is the distance from the boundary of the main channel, which reflects the richness of water resources in each region; Irrigation convenience is the distance from the main ditch, reflecting the convenience of agricultural irrigation in each region; and the distribution of current agricultural land reflects the current situation of agricultural development in each region. The evaluation of social and economic conditions includes five indexes: the economic radiation distance is the distance from the city center, reflecting the strength of the economic radiation from the city center; the convenience of water supply is the distance from water supply facilities, reflecting the convenience of water for urban construction; the convenience of traffic is the distance from the main road, reflecting the convenience of transportation; The convenience of public facilities is the distance from the main public infrastructure, reflecting the convenience of enjoying public infrastructure; the current construction land distribution reflects the current situation of development and construction. The evaluation of river ecological conditions includes three indexes: by analyzing the swing range of the main channel of the Yellow River for many years, the safe range of the downstream river is determined; the current water area distribution mainly analyzes the current river surface distribution and determines the scope boundary of the downstream main channel; the scope of the reserve is determined by analyzing the current situation of the nature reserve and the ecologically sensitive area.

The suitability evaluation of ecological space development is mainly analyzed from three aspects: urban construction area, agricultural production area and ecological protection. Among them, the urban construction area mainly considers the flood control safety conditions and the social economic development conditions and determines the weight value of each evaluation index in the evaluation of socioeconomic conditions according to the actual situation. Through spatial analysis, the location advantage distribution map of urban construction is obtained, and the alternative suitable area for urban construction is preliminarily determined; according to the results of flood control safety evaluation, the suitable area of urban construction is modified to ensure the safety of regional residents and production and construction. Through the superposition analysis of the suitable area and current urban pattern, the adjustment direction and key points of urban construction are analyzed, and the optimization path and specific measures are put forward. The agricultural production area mainly considers the flood control safety conditions and the agricultural development conditions, and determines the weight value of each evaluation index in the agricultural development evaluation according to the actual situation; through spatial analysis, the distribution map of agricultural production advantage is obtained, and the suitable area for agricultural production is preliminarily determined; combining with the results of flood control safety evaluation, the suitable area of agricultural production is modified to ensure the safety of regional agricultural production; Evaluate agricultural production pattern and optimization path according to the scope of the suitable area. The ecological protection area mainly considers the ecological safety conditions of the river course, preliminarily determines the protection area of the ecological safety of the river course according to the scope of the river course and the distribution of the current water area, and determines the ecological protection area in combination with the revision of the scope of the currently defined natural protection area; according to the scope of the ecological protection area, evaluate the ecological security pattern and optimization path.

2.2. Study Area

The total area of the Yellow River floodplain in the new plain area is 126.88km², with a population of 72800. The area is adjacent to the Yellow River in the south, with no mountains and flat and low-lying terrain. It is a plain area in the north of Henan Province. The cultivated land area in the floodplain accounts for nearly half of the total area, the current industry is mainly traditional planting, and some of the lands is transferred to develop ecological agriculture, fruit and vegetable planting, processing industry, leisure tourism, biotechnology and other industries. The traffic in the area is relatively convenient, including the old 107 National Road and the road across the beach, etc.

Taking the plain demonstration area of Yellow River floodplain as the research object, the comprehensive evaluation method of the spatial distribution of the lower reaches of Yellow River proposed above is adapted to carry out the evaluation of basic conditions and the evaluation of the suitability of the ecological space development and determine the suitable areas for the urban construction, agricultural production and river ecological protection in the floodplain, so as to optimize the ecological spatial distribution.

3. Results and discussion

3.1. Evaluation of ecological spatial layout

3.1.1. Evaluation of basic conditions. The evaluation and analysis of flood control safety conditions in the study area are shown in Fig 1.

It can be seen that the area is higher in the West and lower in the East, and the area near the levee is relatively low due to the dike Root River, the current residential area is slightly higher, the overall terrain is relatively flat, and the slope is relatively small.

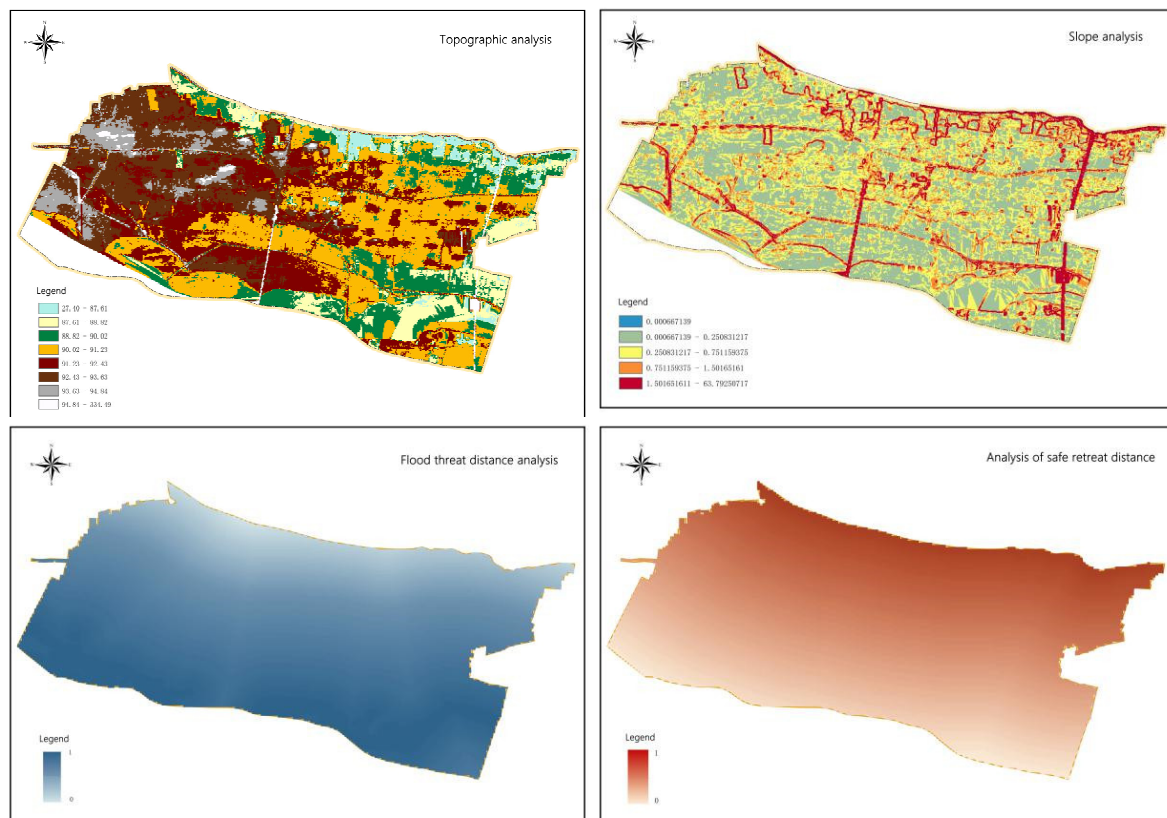


Figure 1. Evaluation and Analysis of Flood Control Safety Conditions

The evaluation and analysis of agricultural development conditions and socioeconomic conditions in the study area are shown in Figure 2 and Figure 3 respectively. It can be seen from the figure that the closer to the main channel, the higher the water resource abundance, the convenient agricultural irrigation conditions, and the socioeconomic conditions are not optimistic.

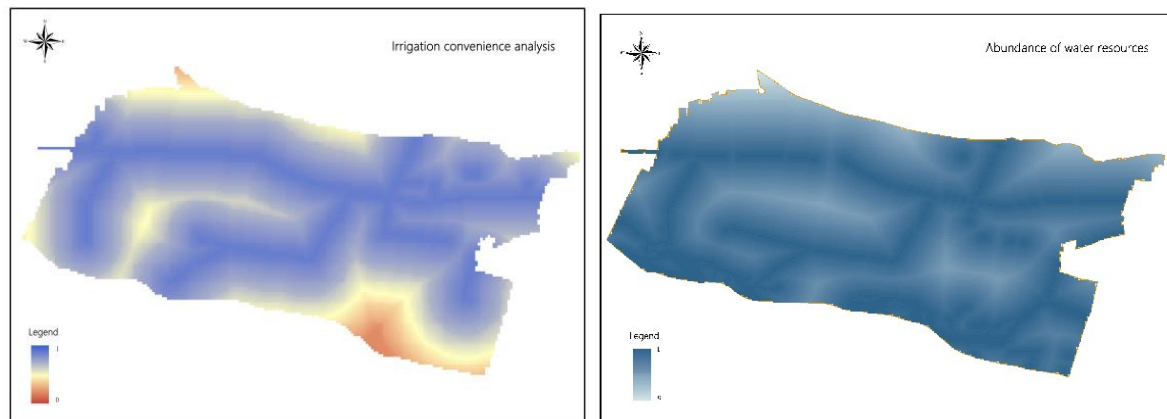


Figure 2. Evaluation and Analysis of Agricultural Development Conditions

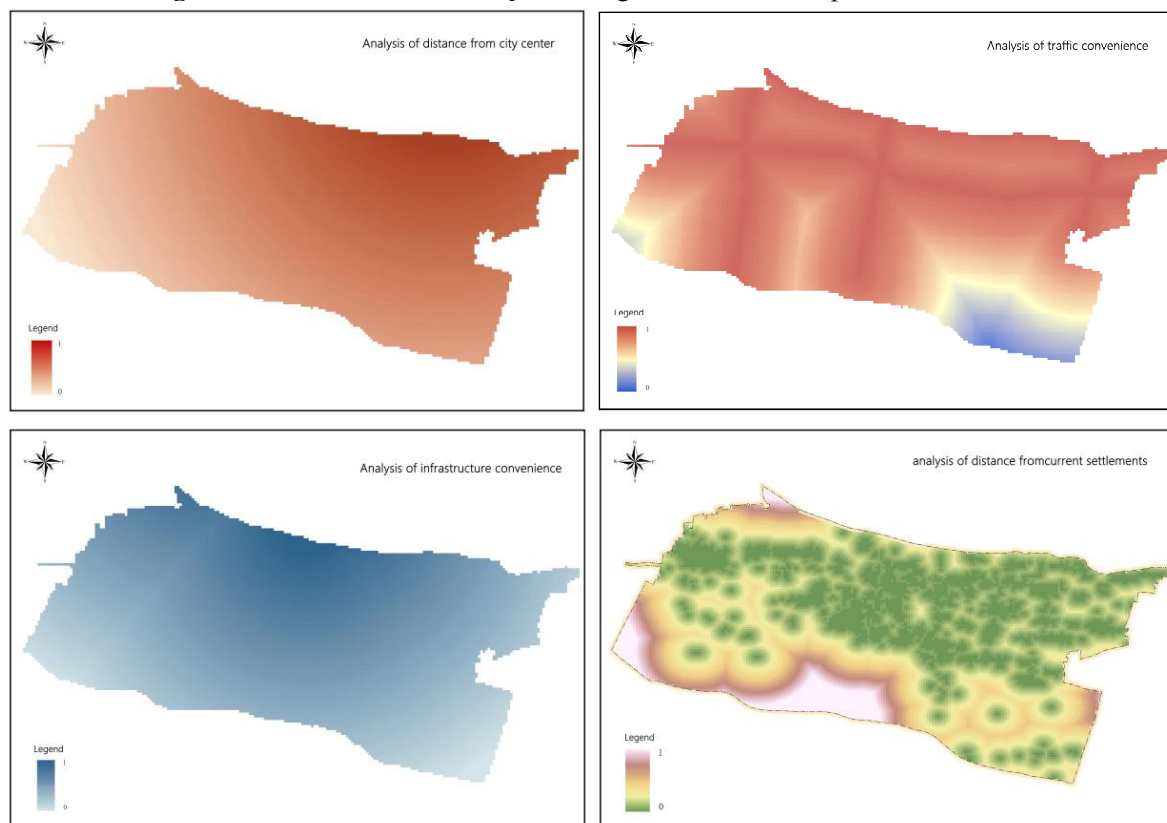


Figure 3. Evaluation and Analysis of Socioeconomic Conditions

According to the control and guidance engineering, the safe range of river crossing in the planning area is drawn, and the core area of the nature reserve, the current river surface boundary and the safe distance of river crossing are considered, see Figure 4 for the determined scope of the ecological protection area. It can be seen that the ecological conditions of the river are insufficient.

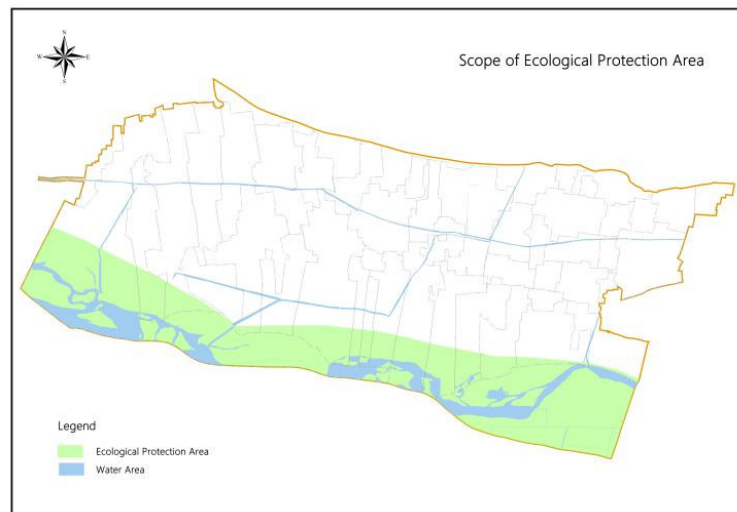


Figure 4. Scope of Ecological Protection Area

3.1.2. Suitability evaluation of ecological space development. Based on the evaluation of socioeconomic conditions, the comprehensive evaluation value of socioeconomic conditions is calculated through spatial analysis, and the location of urban construction in the planning area is shown in Fig. 5.

It can be seen from the figure that the area close to the levee is relatively close to the central urban area, transportation trunk line and public service facilities, with good location conditions and high comprehensive advantage. In addition, it is a suitable area for urban construction in combination with urban development axis belt, relevant policies, and other factors; The soil nutrients in the current agricultural areas are high, which is more suitable for agricultural production activities.

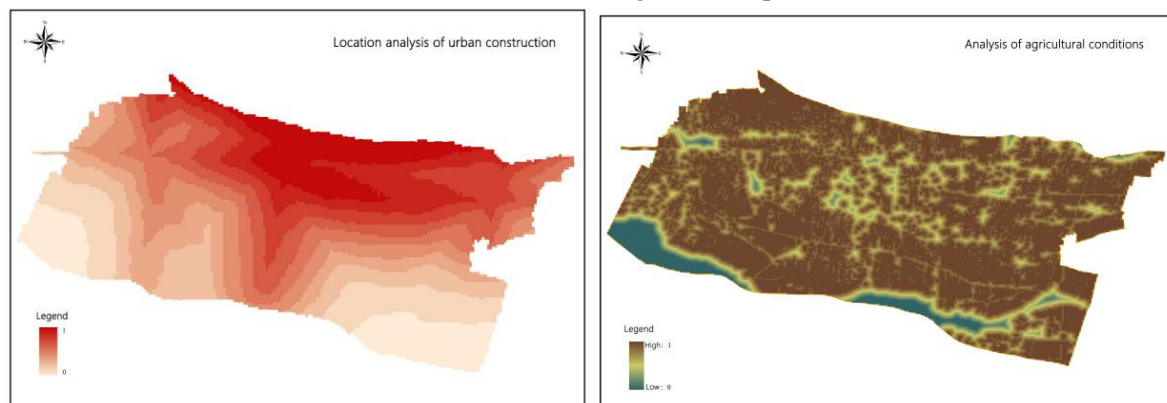


Figure 5. Analysis of Urban Construction Location and Agricultural Production Conditions

3.2. Optimization of Spatial Layout of Planning Area

From the evaluation result of flood control safety condition, it can be seen that according to the submergence depth and flood control standard, the risk of flood disaster varies in different regions, and the risk of flood is relatively small in high-lying areas; the closer to the main channel of the Yellow River, the higher the risk of inundation in case of flood disaster; the farther away from the Yellow River levee, the more difficult it is to evacuate the personnel and property in case of flood disaster. From the perspective of long-term socioeconomic development and public security, the

current terrain conditions in the study area cannot meet the requirements of safety construction. Therefore, to make rational use of the land in the floodplain and meet the needs of local development, the paper adopts the form of building high platform by silting, that is, building high platform along the levee as the area of urban construction, raising the elevation of construction land to above the standard of flood control safety construction in the floodplain of the lower Yellow River to ensure the safety of life and property of urban residents. At the same time, combined with the designated urban construction suitable area, agricultural production suitable area and ecological protection area, the spatial layout of the Yellow River floodplain in the plain demonstration area will be re-planned, and the urban, agricultural and ecological space will be scientifically and orderly arranged as a whole, as shown in Figure 6.

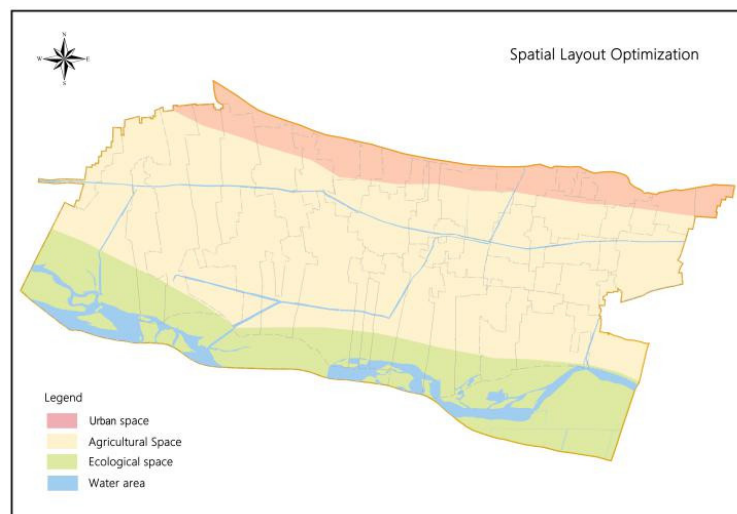


Figure 6. Spatial Layout Optimization of the Yellow River Beach in the Plain Demonstration Area

4. Discussion

The area near the levee in the floodplain has a high concentration, convenient water supply, and obvious location advantage, which is suitable for urban construction. However, due to the unique geographical location of the Yellow River floodplain and the limitation of flood control function of the flood detention and sediment deposition in the floodplain, the flood threat is very great, and it is easy to cause a great deal of disaster loss if urban construction is carried out. In order to solve the contradiction between the safety of flood control and the survival and development needs of the people in the floodplain, according to the actual situation of "the higher the terrain is, the lower the risk of the flood", the "high beach" is built near the levee to increase the elevation of the original area, according to the actual situation, the flood level of 20-year return period or 50-year return period can be adopted, which can not only make rational use of land resources in the floodplain, meet the demands of people's survival and development in the floodplain, but also solve the problems of flood control safety and ensure the safety of people's lives and properties.

The floodplain is located between the main channel and the levee. It is rich in cultivated land, good in soil quality, high in plot concentration, good in irrigation conditions, and suitable for agricultural production. At present, there are a large number of villages in this area, and it is easy to cause economic loss in the case of flood disasters. Therefore, the area should mainly focus on agricultural production and migrate villages.

The main channel of the lower Yellow River and its surrounding areas are responsible for biodiversity maintenance, water conservation, soil and water conservation, wind and sand fixation, and other ecological services, and the ecological environment is sensitive and fragile. Therefore, it is necessary to strengthen the ecological environment protection, reduce the interference of human activities, and restore the ecological environment naturally.

In general, from the levees on both sides to the river channel, they are successively transformed into "high beach", "two beach", "tender beach", with ecological control measures, different functional areas are formed to realize the flood control safety of the lower Yellow River and the floodplain and support the rapid economic development of both sides of the lower Yellow River, as shown in Fig. 7.

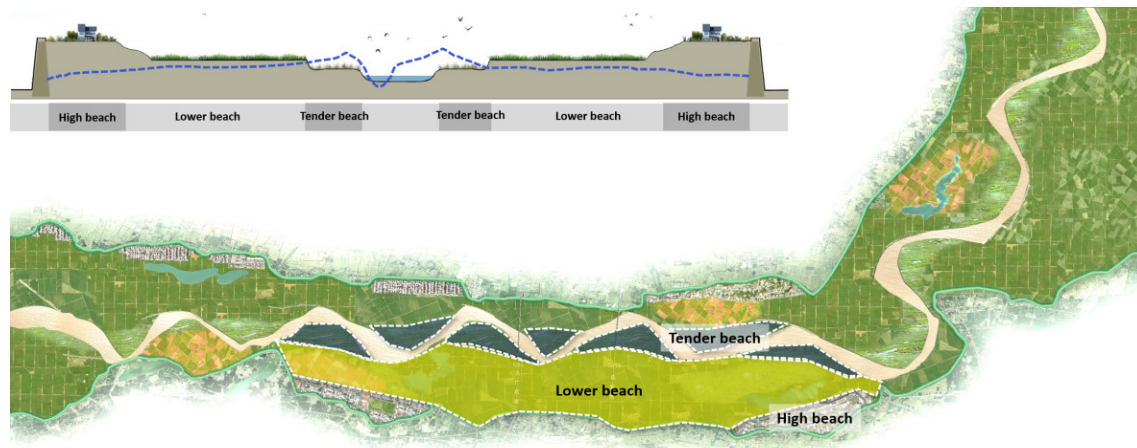


Figure 7. Spatial Layout Optimization of Floodplain in the Lower Yellow River

5. Conclusion

The floodplain of the lower Yellow River is a unique ecological space in the North China Plain, which plays an important role in maintaining the ecological safety of the lower Yellow River. Based on the function orientation, this paper selects all kinds of evaluation factors and constructs a comprehensive evaluation index matrix for the functional spatial layout of the floodplain in the lower Yellow River; taking the Yellow River floodplain in the plain demonstration area as the research object, the flood control safety conditions, the agricultural development conditions, the socioeconomic conditions, and the river ecological conditions are comprehensively evaluated, and the conditions that need to be considered in urban, agricultural and ecological areas are comprehensively analyzed, the suitable areas for urban construction, agricultural production and the ecological protection areas are defined respectively. At the same time, combined with the requirements of flood control safety in the floodplain, the new idea of optimizing the spatial pattern of the floodplain is put forward. The evaluation and optimization method of ecological spatial layout proposed in this paper can be applied to the whole floodplain of the lower Yellow River, the way of ecological dredging and sediment deposition is used to shape the floodplain, forming the spatial pattern of the high beach, two beach and tender beach, as the base of life, production, and ecology. By adjusting the cross-section shape of the river, shaping the three beaches, managing them in different areas, coordinating the relationship between life, production and ecology, and coordinating the balanced development inside and outside the floodplain.

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