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Analysis and research on the plan of Yihe River rerouting line

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Abstract: The Yihe river channel is from Liujiadokou to Beijing-Hangzhou Canal. By analyzing the restricting factors of the basic conditions of the resume navigation of the inland river, this paper puts forward three line schemes, and carries on the utilization of river and waterway, the guarantee of the water resources, sluice dam and bridge, artificial canal. It is concluded that line 3 is the optimal rerouting line. The optimal line is obtained: Liujiadaokou Sluice→Sulu Boundary→ Shiba Village→ Huangnihe River→Chenghe River→Beijing-hang Canal. The total length of the waterway is 86.2 km, of which 54.5 km is in Shandong Province and 31.7 km in Jiangsu Province.

1. Introduction

There are a large number of rivers in Linyi, and the water system is developed and the water quantity is abundant. It mainly includes four major river systems of the Huaihe River Basin: Yihe River, Shuhe River, Zhong Canal and Binhai River. The Yihe River is the only river with navigation potential in Linyi. After resumption of navigation, it will become an important waterway for Linyi to communicate with northern Jiangsu and the Yangtze River Delta Economic Zone. Linyi will replenish the shortboard of waterway transportation and integrate it into the development battle of the Yangtze River Economic Zone. It is of great strategic significance to promote regional economic development, implement the construction of ecological civilization, adjust the industrial layout, realize the comprehensive utilization of water resources and improve the comprehensive transportation system.

In view of the importance of the re-navigation project, domestic scholars have studied the re-navigation of several inland rivers, such as Cao Y [1] On the Feasibility and necessity of resuming Navigation in Wanfuhe River. Song J B [2] Speeding up the Waterway Construction from Dongping Lake to Jining Section of the Beijing-Hangzhou Canal. Wang Y X [3] Strategic Conception of the Feasibility of resuming Navigation in the South Canal (Hebei Section). Zuo H C [4] The engineering measures and significance of resuming navigation in Hongshui River (Guangxi section).

By analyzing the restrictive factors such as water resources, sluices and dams, bridges across the river, channelization and the connection of downstream river, the paper puts forward three line schemes, and compares the three schemes from the technical feasibility, and recommends the optimal renavigation line [5].

2. Introduction of line scheme

2.1. Line 1: Liujiadaokou Sluice→ Sulu Boundary→ Yihe River→ Luoma Lake→ Beijing-hang Canal. Line 1 makes full use of the river channel of the Yihe River. The total length of the line is 97.0 km, including 54.5 km in Shandong Province and 42.5 km in Jiangsu Province. There are six river-blocking



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dams along the way, including Lizhuang, Tushan, Hongfusi, Matou, Shouxian Village and Huayi Sluice. There are 11 large bridges such as G2 Bridge, G310 Bridge, Longhai Railway Bridge and Lianhuo Expressway Bridge (one of which is under construction), including 5 bridges in Shandong Province. See Figure 1 for details.

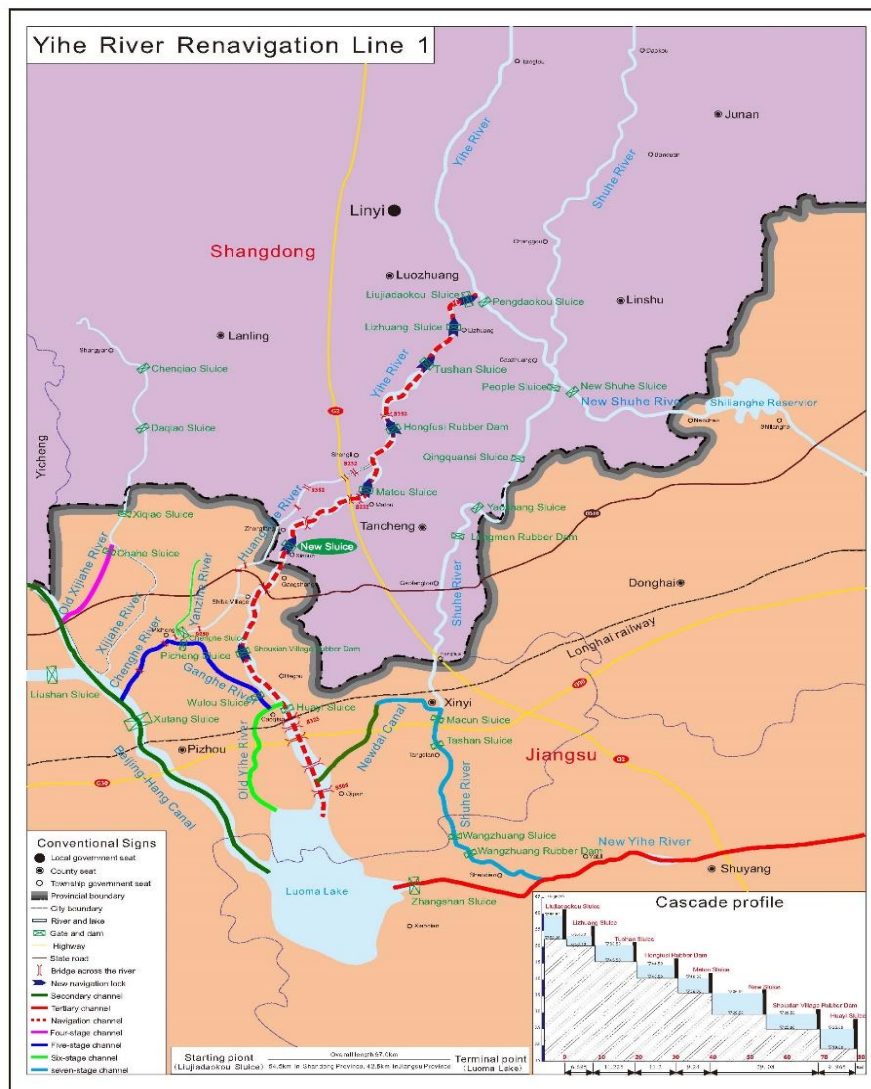


Figure 1. Yihe River Renavigation Line 1.

After the rebuilding of the dam above Matou Sluice, the channel between Liujiaokou Sluice and Matou Sluice will basically be channelized. The 12 km reach between Matou Sluice and Shouxian Village Rubber Dam is now a natural reach. Below Huayi Sluice is a natural river section. Because of the low water level of Luomahu Lake, the river has been dry for a long time, the flood season rises and the dry season cuts off.

This scheme is the best traditional one, but because there are many dams and bridges along the way, and the bridge reconstruction project and ship lock construction project are huge. It is necessary to build a new sluice between Matou Sluice and the Shouxian Village Rubber Dam to achieve channelization of the river section. It is basically in a state of water shortage. The implementation of the resumption of the program is difficult, the investment cost is high, and the water resources guarantee rate of some river sections is insufficient, and the possibility of full-line navigation is small.

2.2. Line 2: Liujiadaokou Sluice→ Sulu Boundary→ Huayihe Sluice→ Ganghe River→ Chenghe River→ Beijing-hang Canal

Line 2 is using Yihe River, Ganghe River and Chenghe River. Above the Huayi Sluice, the line is bypassed through the Beijing-Hangzhou Canal to avoid the Huayi Sluice, Longhai Railway Bridge and Lianhuo Expressway Bridge. Ganghe River and Chenghe River are navigable rivers with low current level. In < Planning revision of Xuzhou Waterway Network >, Ganghe River and Chenghe River are five-stage channel. The total length of the line is 106.4 km, including 54.5 km in Shandong Province and 51.9 km in Jiangsu Province (23.9 km in Yihe River, 15.5km in Ganghe River, 12.5 km in Chenghe River). Along the river there are 5 sluices and 7 large bridges. In addition, there are 7 small bridges along Ganghe River, if you want to reach channel grade, you still need to be renovated. See Figure 2 for details.

The river channel condition of Yihe River on this line is similar to that of line 1, and it is still necessary to construct the new sluice between Matou Sluice and the Shouxian Village Rubber Dam. This line goes around to the Beijing-Hangzhou Canal and avoids some important bridges and sluice dams. The water resources are guaranteed to some extent, and the implementation difficulty of the project is smaller than that of Line 1. However, there are more villages and towns along the Ganghe River, the width of the channel is smaller, and it is more difficult to upgrade and expand the waterway.

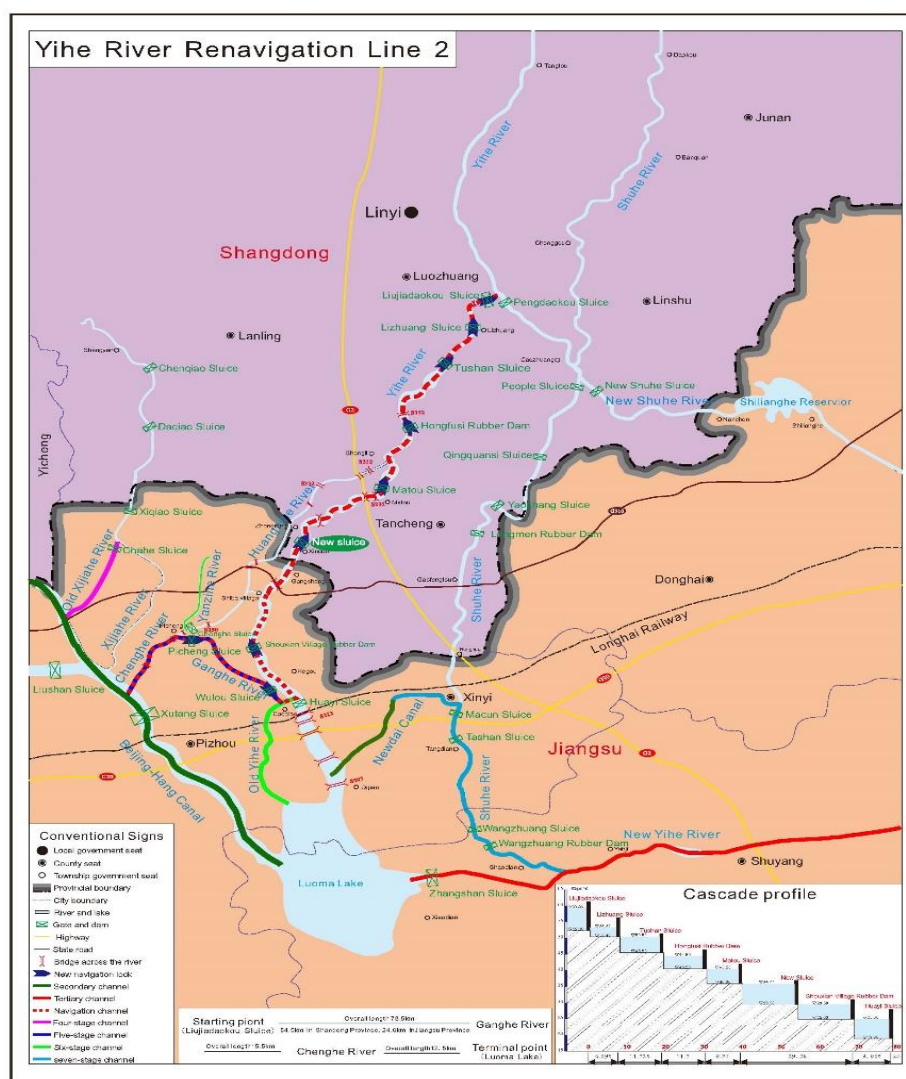


Figure 2. Yihe River Renavigation Line 2.

2.3. Line 3: Liujiadaokou Sluice→ Sulu Boundary→ Shiba Village→ Huangnihe River→ Chenghe River→ Beijing-hang Canal

The Line 3 is a bypass scheme, mainly using the Yihe River, Huangnihe River, Chenghe River, and finally arriving at the Beijing-Hangzhou Canal, most of which use natural rivers. The Scheme focuses on breaking the Yihe River embankment, building ship locks, and artificially dredging river channels between Shiba Village and Yangzhuang Village to connect Yihe River and Huangnihe River. At present, the main river channel between Shiba Village and Yangzhuang Village is a pond with a width of about 300 m, which can become a waterway without a lot of excavation. The total length of the channel is 86.2km, of which the Yihe reach is 61.7 km, the artificial river is 2.4 km, the Huangnihe River is 6.4 km and the Chenghe River is 15.7 km. There are 5 existing river-blocking dams and 7 large bridges. See Figure 3 for details.

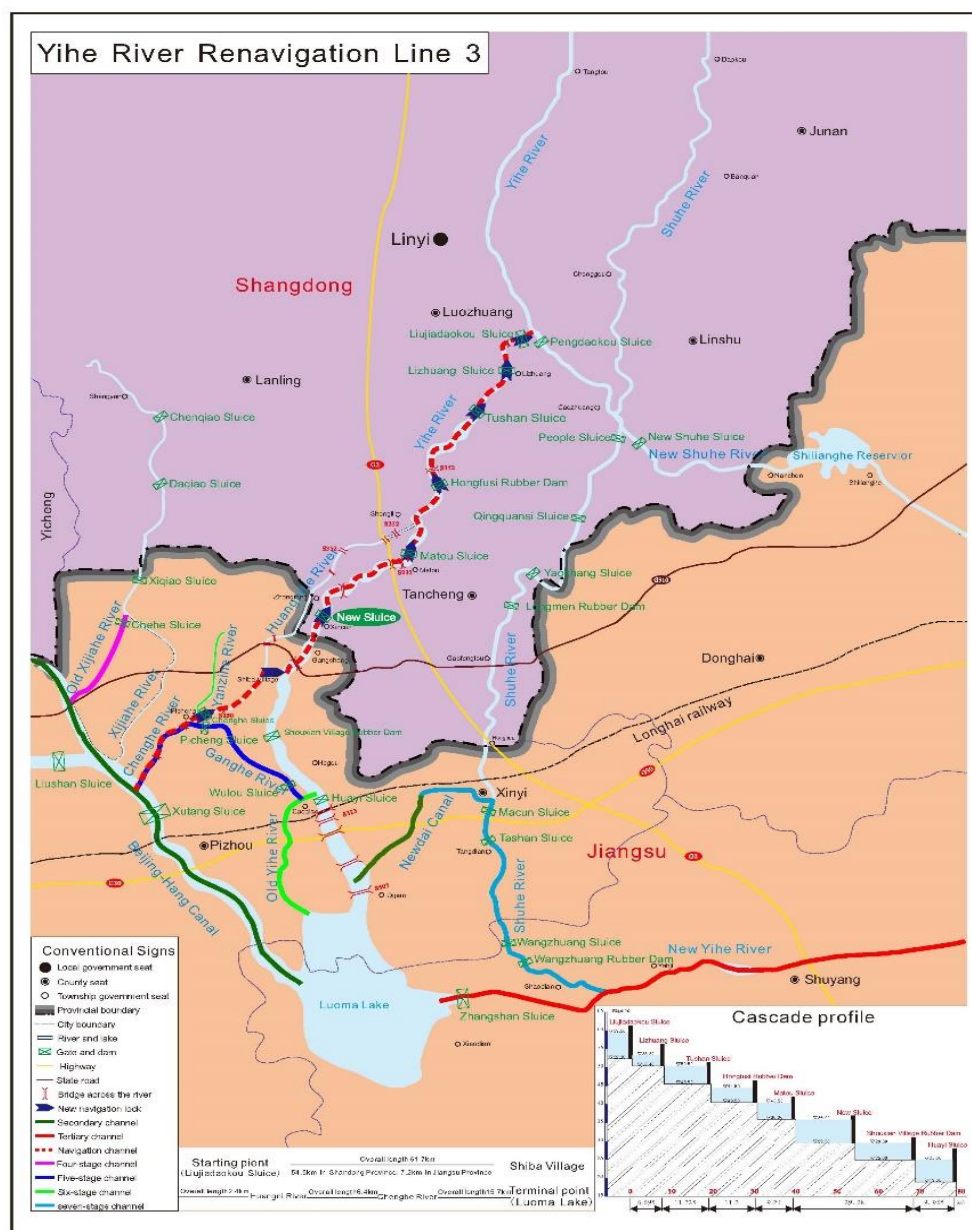


Figure 3. Yihe River Renavigation Line 3.

The Yihe river condition of the line is similar to that of the line, and it is still necessary to construct the river course between the cascade channelized Matou Sluice and the Shouxian Village Rubber Dam. This line goes around to the Beijing-Hangzhou Canal, but avoids the dam and large bridge on the Yihe River in Jiangsu Province. There are sluices on the Chenghe River, and the water resources are guaranteed to a certain extent. In this scheme, the artificial river connecting Yihe River needs to break the Yihe River embankment at Shiba Village and build new navigation lock. The width of Huangnihe River is about 100 m, so there is room for channel upgrade, widening and upgrading. This scheme mainly uses natural rivers with moderate mileage, relatively small investment and less difficulty in navigation.

3. Comparative analysis of technical feasibility

The resumption of navigation of Yihe River is restricted by many factors. In this paper, the statistical data of river name, river mileage, channelization project, navigation engineering, large bridge and artificial canal involved in each route are listed and explained. Details are given in Table 1.

Table 1. Status of the scheme of Yihe River renavigation line.

Line scheme	River name	Mileage (km)	Channelization engineering (seat)	Navigation engineering (seat)	Large bridge (seat)	Artificial canal (km)
Line 1	Yihe River	97	1	6	11	
	Subtotal	97	1	6	11	
Line 2	Yihe River	78.4	1	5	6	
	Ganghe River	15.5		2		
	Chenghe River	12.5				
	Subtotal	106.4	1	7	6	
	Yihe River	61.7	1	4	6	
Line 3	Artificial canal	2.4		1		2.4
	Huangnihe River	6.4				
	Chenghe River	15.7		1		
	Subtotal	86.2	1	6	6	2.4

3.1. Utilization of watercourses and channel

According to the comparison and analysis of the mileage and the utilization ratio of the existing channel and the waterway the shorter the whole route mileage is, the higher the proportion of the existing channel, in particular the higher the proportion of the waterway, the less the artificial channel is needed for the channel regulation and the external engineering, The smaller the difficulty of the project implementation.

Line 1 all use the river channel of Yihe River, and the mileage of the river is the longest compared with other schemes. Line 2 and 3 use the river course mileage of the Yihe River to be moderate. Line 2 uses the river channel of Jiangsu Province, the channel of Chenghe River, and line 3 uses the channel of Chenghe River. Line 3 requires the construction of small artificial rivers connecting the Yihe River and the Huangnihe River. Details are given in Table 2.

Table 2. Comparison of current channel and channel utilization.

Comparative content		Mileage (km)	Channel utilization (seat)		Waterway utilization (seat)		Artificial canal utilization (km)	
			Mileage	Scale	Mileage	Scale	Mileage	Scale
Line scheme	Line 1	97.0	97.0	100%				
	Line 2	106.4	78.4	74%	28.0	26%		
	Line 3	86.2	68.1	79%	15.7	18%	2.4	3%

In conclusion, this section analyzes and compares the utilization ratio of three lines from channel, waterway and artificial canal utilization. Among them, the mileage of the line 1 is 97.0 km, the mileage of the river course is 97.0 km, and the utilization rate is 100%, no waterway and artificial channel. Line2 mileage 106.4 km, of which 78.4 km channel mileage, 74% utilization rate, 28.0 km waterway mileage, 26% utilization ratio, no artificial channel. Line 3 mileage 86.2 km, of which river mileage 68.1km, the utilization ratio is 79%, the waterway mileage is 15.7 km, the utilization ratio is 18%, the artificial channel mileage is 2.4 km, and the utilization ratio is 3%. Considering the utilization ratio of the existing waterways, lines 2 and 3 have obvious advantages, but the excavation of the artificial canal on line 3 needs to break the Yihe River embankment. It is difficult to implement, so the synthesis of line 2 is better.

3.2. Comparison of the degree of water resources security

The water source of the Line 1 is Yihe River. According to the above analysis, after the channel between Liujiadaokou Sluice to Huayi Sluice is channelized, the shipping water can be basically guaranteed, but there is a seasonal shortage. The river course from Huayi Sluice to Luomahu Lake is a natural section because of the low water level, long dry river course, high water in flood season and dry season. If the channel level is to be reached, it is still necessary to control the river channel.

The water sources in Line 2 are Yihe River, Ganghe River and Chenghe River. Although the river runoff is not big, it can satisfy the Chenghe River, Huangnihe River and Yanzihe River, and there are Wulou Sluice, Picheng Sluice control, water quantity has a certain degree of protection. The upper reaches of Chenghe River have Huangnihe River and Yanzihe River, water resources security is high.

The water sources in Line 3 are Yihe River, Huangnihe River and Chenghe River. Chenghe River. Huangnihe River is basically a natural state, Wuhe River and Shagou River into the Huangnihe River, downstream there are Chenghe Sluice control, the water guarantee rate is high.

A comparative analysis of the degree of water resources security can be found in the Table 3 below.

Table 3. Comparison of water resources security.

Comparative content	Line scheme		
	Line 1	Line 2	Line 3
Shipping water source	Yihe River	1.Yihe River 2.Ganghe River 3.Chenghe River	1.Yihe River 2.Huangnihe River 3.Chenghe River
Water source assurance	Lower part of the reach	Slightly higher	Higher

In conclusion, this section makes a detailed analysis of three lines from shipping water source and water source assurance, and compares them. Among them, line 3 has a higher comprehensive advantage in the aspect of water supply guarantee rate, so it can be concluded that line 3 is better.

3.3. Comparison and analysis of navigation lock, canalization and canal engineering

Yihe River does not have navigation capacity at present, but it has great potential. There is no navigation lock in the construction of water conservancy facilities such as river sluice and dam. In order to realize navigation, every existing sluice and dam facilities need to be built. Line 1 needs to build 6 navigation locks, line 2 needs to build 7 navigation locks, line 3 needs 6 navigation locks. The overall layout of each gate and dam facilities shows that the total width of each river dam below Liujiadaokou Sluice crossing is 300~800 m, which has lock construction space and can meet the requirements. The sluice dams on the river Ganghe River and Chenghe River in Xuzhou cannot meet the requirements, so it is necessary to upgrade and renovate them at the same time.

The Channelization has been basically realized from below Liujiadaokou Sluice to Matou Sluice. Most of the 27.3 km reach from Matou Sluice to Shouxian Village Rubber Dam belongs to natural river. The bottom slab elevation of Matou Sluice is 36.0m, the design water level of Shouxian Village Rubber Dam is 29.5 m, and the water level difference between the two sluice dams is 6.5 m, which cannot be connected with each other. It is necessary to construct a new sluice between the two dams in order to realize the channelization of the reach. As shown in Table 4.

Table 4. Comparison of navigation lock, canalization and artificial canal.

Comparative content	Line scheme		
	Line 1	Line 2	Line 3
Navigation lock (seat)	6	7	6
Canalization (seat)	1	1	1
Artificial canal (km)	0	0	2.4

To sum up, this section analyzes and compares three lines from three aspects: the number of new lock seats, the number of channelization projects and the length of artificial river course. Among them, lines 1 and 3 need to build 6 navigation locks and line 2 need to build 7 navigation locks. All three lines need to build a channelization project, and line 3 needs to build artificial channel of 2.4 km. Therefore, it can be concluded from the number of engineering construction that line 1 is less. The advantage of line 1 is the highest.

3.4. Comparison of bridges across the river

In each line scheme, there are a large number of bridges across the river. Line 3 is the least, for 5 important bridges, line 1 is the most, for 11 bridges. The comparative analysis of the main span bridges is shown in the Table 5 below [6].

Table 5. Comparison of main bridges across the river.

Comparative content	Line scheme		
	Line 1	Line 2	Line 3
Railway bridge (seat)	1		
Expressway bridge (seat)	2	1	1
National highway and other important bridges (seat)	8	5	4

This section analyses and compares three lines from the degree of difficulty and the number of bridge seats. There are one railway bridge, two expressway bridges, eight national provincial roads and other important bridges along line 1, one expressway bridge and five national provincial roads and

other important bridges along line 2, and one expressway bridge and four national provincial roads and other important bridges along line 3. In terms of the complexity of construction, it can be concluded that line 3 is less, which is more advantageous than the other two schemes.

3.5. Comparison of technical feasibility

Through the above technical feasibility analysis, all aspects of the analysis summarized as follows: As shown in Table 6.

Table 6. Comparison of technical feasibility [6].

Order number	Comparative content	Significance	Comparison result recommendation scheme
1	Utilization of watercourses and channel	Important	Line 2
2	Water resources guarantee	Very important	Line 3 and Line 2
3	Lock engineering	Ecumenic	Line 3 and Line 1
4	Canalization engineering	Ecumenic	Line 3 and Line 1
5	Artificial channel	Important	Line 1 and Line 2
6	Bridges across the river	Very important	Line 3

Finally, this paper compares three lines from six aspects: River course, waterway utilization ratio, water resources guarantee, ship lock engineering, canalization engineering, artificial river course and river-crossing bridge. Among them, line 1 is very important, important is 1, general is 2; line 2 is very important, important is 2, general is 0; line 3 is very important, important is 0, general is 2, route 3 is known as line 3. For the optimal route, it has obvious advantages in the distribution of the importance of each comparative factor.

4. Conclusion

Through the comparative analysis of technical feasibility, each of the three line schemes has its own advantages and disadvantages. By synthesizing various factors, line 3 is recommended as the line scheme of Yihe River renavigation channel. The optimal line is: Liujiadaokou Sluice→ Sulu Boundary→ Shiba Village→ Huangnihe River→ Chenghe River→ Beijing-hang Canal, with the overall length of 86.2 km, of which 54.5 km in Shandong Province and 31.7 km in Jiangsu Province.

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