Study on the Functional Positioning and Construction Plan of Inland Anchorage Service Area in Yuyao Port, Hangzhou-Ningbo Canal

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Abstract: Inland waterway service zones are key nodes in the public service system for inland waterway transportation. Its planning and construction standards directly affect the efficiency of waterway operations, the ability to prevent and control ship pollution, and the quality of crew services. This article takes the anchoring service area of Yuyao Port on the Hangzhou-Ningbo Canal as the research object. The functional positioning of the anchorage service area, the matching demonstration of transportation volume, the verification of berth scale and the comparison of construction schemes were systematically expounded. The research proposes a phased reserve strategy of "operating 1,000 tons in the near term and developing 2,000 tons in the long term". A three-level functional system of "basic functions-enhanced functions-reserved functions for the future" has been established. The analysis of volume matching indicates that the 6-berth scheme exhibits operational characteristics of "basic matching under normal conditions and a gap at peak times". The scheme comparison and selection are carried out from dimensions such as functional integrity, land use conditions, safety and environmental protection, and investment economy. It is recommended that the West bank Comprehensive Ecological Service Area be selected as the first-phase implementation plan and the east bank logistics collaborative service area as the second-phase expansion plan. The research results can provide references for the planning of water service areas in high-grade inland waterways.

Keywords: Inland Waterway Transport; Anchorage Service Area; Berth Capacity Planning; Land Swap; Grand Canal; Multi-Modal Transport

1. Introduction

Inland waterway shipping is an important component of China's comprehensive transportation system, featuring comparative advantages such as large transport capacity, low energy consumption, small land occupation, and light pollution. With the in-depth advancement of the development of the Yangtze River Economic Belt and the integrated strategy of the Yangtze River Delta. The construction of high-grade inland waterway networks has been continuously accelerating. The trend of larger and more specialized vessels has become increasingly prominent. The shortcoming of insufficient public service capacity in inland waterway shipping has gradually emerged. In 2025, the proposal "On Accelerating the Construction of Inland Waterway Service Areas in China" was listed as a key proposal of the National Committee of the Chinese People's Political Consultative Conference. It pointed out that there are only 19 service areas along the 2,800 kilometers of the main channel of the Yangtze River, with an average distance of 150 kilometers, which is highly inconsistent with the daily freight volume of over 13.57 million tons. The density of inland waterway service areas across the country is only about 3% of that in the expressway system. In the same year, the "Opinions on Promoting High-Quality Development of Inland Waterway Shipping" issued by six ministries and commissions explicitly stated that "a number of water service areas with complete functions and efficient services should be built." In 2026, the transportation industry standard "Service Specifications for Inland Waterway Water Service Areas" (JT/T 1583-2026) was officially released and implemented, marking a new stage of standardized and normalized development in the construction of inland waterway water service areas.

There has been a certain accumulation of research on the functions and layout of inland waterway service areas. Luo Xiaoguang and Zhu Jie [1] systematically expounded the design key points such as the classification, scale and function of anchor service areas, and proposed the development prospects based on the design concept and operation situation of anchor service areas in Zhejiang Province. Yang Hairong et al. [2] conducted a survey on the intention of waterway service demands, and deeply explored the functions of inland waterway service areas, the classification of service areas, and the layout forms under different waterway conditions. Du Ke [3] analyzed the functional demands and influencing factors of some inland water service areas in the Yangtze River Economic Belt, and put forward functional positioning and development suggestions. Ding Tianping and Liao Peng [4], based on the operation experience of waterway service areas in Jiangsu region and the questionnaire survey of crew members, focused on analyzing the experience and implications of the functional configuration of waterway service areas. Li Jian [5] proposed the construction ideas of digital inland waterway water service areas from the perspective of "Internet +". Liu Yu et al. [6] constructed a green evaluation index system for water service areas applicable to various construction types. Li Jiabin [7] explored the innovation of digital operation models for inland waterway water service areas and proposed to enhance operational efficiency through intelligent sensor networks, edge computing, and digital twin technologies. Xu Xuan [8] analyzed the key mechanisms of waterborne anchorage management in inland waterways and proposed strategies for anchorage reservation, dynamic allocation and emergency dispatch. Xu Xuan [9] further studied the key technologies for intelligent monitoring of berths in inland river mooring areas and constructed a real-time perception system for berth status based on multi-source sensor fusion. Gao Feng [10] discussed the management system of the water mooring area of the inland waterway smart channel and proposed an intelligent dispatching method based on AIS data and real-time water level information. The above-mentioned research provides methodological support for the planning of inland waterway service areas. However, systematic studies on the functional positioning, volume matching and scheme comparison of service areas under specific port conditions are still insufficient, especially lacking a quantitative argumentation method for berth scale that starts from the demand side and is driven by data.

The Hangzhou-Ningbo Canal is an important high-grade inland waterway connecting Hangzhou and Ningbo. The Yuyao Port Area undertakes functions such as inland container transportation in the western part of Ningbo, organization of combined road-rail-water transport, port and shipping public services, and water safety guarantee. To properly address the waiting needs of ships for locks and deal with emergency situations, Yuyao plans to set up a waterborne berthing service area in the waters near Shushan Lock. With the continuous growth of container transportation volume in Yuyao Port Area and the increasing trend of larger ships, the existing decentralized temporary service facilities are no longer capable of meeting the medium and long-term development needs of the port area. There is an urgent need to build a comprehensive anchoring service area with complete functions and efficient services. This paper takes the implementation plan of the anchoring service area of Yuyao Port on the Hangzhou-Ningbo Canal as a case study, and conducts a systematic research from the dimensions of functional positioning, volume matching, berth scale argumentation and construction plan comparison, with the aim of providing a reference for similar inland waterway water service area projects.

2. Functional Positioning and Design Parameters

2.1 Service Area Functional Grading System

According to the "General Design Code for Inland Waterway Service Areas" (JTS/T162-2021) and the "Service Code for Inland Waterway Service Areas" (JT/T1583-2026), inland waterway service areas can be classified into two types based on functional configuration: comprehensive service areas and general service areas. The general service area mainly provides basic services such as ship berthing and the recycling of domestic garbage and sewage. In addition to the general service area, the comprehensive service area should also provide extended services such as emergency rescue, water and gas refueling, and shopping for daily necessities. From the practical experience of waterway service areas in Jiangsu and Zhejiang regions [1,2,4], the initial configuration of service functions mainly drew on the relevant technical requirements of expressway service areas, and later gradually formed a functional system that adapted to the characteristics of inland waterway shipping. It mainly includes eight types of functions: anchoring, refueling, gas and water filling, catering and accommodation, daily life supplies, maintenance and spare parts, shore power network, safety, health and environmental emergency response, and cargo flow information.

This study, in combination with the development needs and on-site conditions of Yuyao Port Area, has constructed a three-level functional system of "basic functions-enhanced functions- reserved functions for the future", which serves as the control boundary for the construction sequence, investment phases and operation access.

The basic functions are the service capabilities that a service area must immediately possess after being put into operation, including: Berthing (to meet the short-term berthing and waiting for the lock requirements of ships), shore power connection (providing low-voltage shore power interface) Meet the electricity demand during the ship's mooring period, provide living supplies (offer fresh water supply and daily necessities), provide short-term rest for crew members (offer basic services such as rest, catering and bathroom), receive pollutants (classify and receive domestic garbage, domestic sewage and oily sewage from ships) and provide emergency support (equip with basic fire-fighting, life-saving and anti-pollution emergency supplies).

Enhanced functions are the service capabilities that are gradually expanded after the operation of the service area becomes stable, including: Ship maintenance (providing minor repair and emergency repair services), energy replenishment (diesel and LNG refueling), intelligent dispatching (ship reservation, berth allocation and queue management), environmental protection pre-treatment (pre-treatment of oily wastewater, temporary storage of hazardous waste) and port and shipping information services (release of information such as water level, weather and lock navigation status).

The long-term reserved function is the flexible capacity reserved to adapt to the upgrading of waterways and the development trend of green shipping, including: Service capacity for 2,000-ton class vessels (reserved for wharf structure and water depth), energy replenishment for new energy vessels (reserved for charging piles and battery swapping facilities), high-power shore power (to meet the high-load power demand of large vessels during berthing), expansion of smart supervision (expansion of video surveillance, AIS data fusion and intelligent analysis functions), and improvement of ecological display (wetland restoration, ecological science popularization and green port area "Display." The above-mentioned functional classification is in line with the service grade division standards of the "Service Specifications for Inland Waterway Water Service Areas", providing a framework basis for subsequent operation management and service evaluation.

2.2 Design Representative Ship Types and Water Depth Control

The selection of ship types is the core basis for the design of berth dimensions, wharf structure and water depth in service areas. This project adopts a phased strategy of "operating 1,000 tons in the near term, developing 2,000 tons in the long term, and reserving the structure and the front water area for 2,000 tons". The main dimensions of a 1,000-ton inland waterway cargo ship are approximately 60.0 meters in total length, 10.8 meters in total width, and 2.6 meters in full-load draft. The main dimensions of the 2,000-ton control vessel type are approximately 67.6 meters in total length, 13.8 meters in total width, and 3.2 meters in full-load draft.

The designed water depth at the quay front is determined based on the full-load draft of 3.2 meters for the 2,000-ton class vessel type, taking into account the surplus water depth of 0.8 meters, and is taken as 4.0 meters. Based on the designed low water level of ▽0.33m (85 National Elevation reference), the dredging bottom elevation is temporarily taken as ▽-3.67m. This controlled elevation not only meets the berthing requirements of 2,000-ton vessels in the future but also avoids the need for large-scale secondary dredging and renovation after the recent completion of 1,000-ton construction. It embodies the engineering economic concept of "one-time construction, long-term applicability".

3. Volume Matching and Berth Scale Argumentation

3.1 Volume Conversion and Vessel Number Calculation

Service Area Scale Argumentation requires converting TEU volume into freight volume, vessel number and service invocation demand, which is the core basis for determining the number of berths. In this study, 12t/TEU was adopted as the median value for freight volume conversion, and 10t/TEU and 14t/TEU were used as sensitivity intervals for boundary verification. In the near term, it is calculated at an average of 50 TEUs per vessel for 1,000-ton class ships, and in the long term, it is calculated at an average of 100 TEUs per vessel for 2,000-ton class ships. The calculation results are shown in Table 1:1.5 million TEUs in 2015 correspond to an average of approximately 90.9 vessel trips per day. If the 2,000-ton class becomes regular in operation by 2040, the loading capacity of each vessel will increase, reducing the average daily number of ships to approximately 66.7. From the conversion results, it can be seen that in the long term, if 2,000-ton vessels can be organized for regular navigation, although the total TEU scale increases from 1.5 million TEU to 2.2 million TEU, the number of converted vessels will increase by different proportions. This indicates that the scale of service areas cannot be simply linearly expanded based on the total number of TEUs, but should take into account factors such as the large-scale of vessel types, berth occupancy time, service invocation ratio, and peak dispatching requirements comprehensively.

Table 1. Volume Conversion and Vessel Number Calculation Table

Year	Ship Type	Container Volume (10,000 TEU/year)	Equivalent Freight Volume (10,000 tons/year)	Equivalent Container Capacity per Ship(TEU/ship)	Annual Number of Vessels (vessels/year)	Average Daily Number of Vessels (vessels/day)
2035	1000-ton class	150	1,800	50	30,000	90.9
2040	2000-ton class	220	2,640	100	22,000	66.7

To enhance the adaptability of the planning scheme to the upgrading progress of the waterway and lock, this study conducted a scenario sensitivity analysis of the demand in 2040. If the waterway locks are not fully upgraded by 2040 and the majority of vessels are still 1,000-ton class (50 to 64 TEUs per vessel), the average daily number of vessels will increase to approximately 104 to 133 per day. The 6-berth service system may shift from normal basic coverage to a relatively tight capacity. At that time, flexible measures such as mobile berths, shore power expansion, and appointment-based dispatching need to be initiated.

3.2 Service Invocation Demand Calculation

The anchorage service area does not provide a full range of services for each passing vessel. The actual service demand depends on multiple factors such as the vessel's voyage, schedule, fuel replenishment cycle, shore power connection habits, crew living supplies, pollutant reception system, and sudden maintenance needs. From the perspective of service area operation experience [4,7], its own "self-sustaining function" is relatively weak, and its sustainable development capacity has always been challenged. Therefore, the configuration of service functions needs to precisely match actual demands to avoid excessive construction causing idle resources.

This study adopted the method of combined verification of benchmark values and sensitivity. The benchmark scenario is calculated based on a comprehensive service invocation ratio of approximately 40%, and sensitivity rechecks are conducted for four groups of invocation ratios: 30%, 35%, 40%, and 45%. In the near term of the scheme stage, a comprehensive service invocation ratio of 35% is estimated. In the long-term upgrade scenario, considering the enhancement of environmental protection supervision and comprehensive service functions, a comprehensive service invocation ratio of 40% is estimated. The peak days shall be verified at 1.30 times the average daily number of served vessels. The calculation results (Table 2) show that the recent regular service demand is approximately 32 voyages per day and the peak demand is about 41 voyages per day. In the long-term upgrade scenario, the normal number is approximately 27 per day and the peak number is about 35 per day. Under the scenario of incomplete upgrade, service demand may significantly increase to approximately 36 to 53 voyages per day, with a normal level and a peak of about 47 to 69 voyages per day.

Table 2. Service Call Requirement Calculation Table

Year/Scenario	Average Daily Ship Calls (ships/day)	Overall Service Call Utilization Rate	Average Daily Service Ship Calls	Peak Service Ship Calls	Calculation Notes
2035	90.9	35%	31.8	41.4	The fleet consists primarily of 1,000-ton class vessels; service frequency is high, while the service duration per vessel is relatively short
2040 (Upgraded Scenario)	66.7	40%	26.7	34.7	The fleet will consist mainly of 2,000-ton class vessels
2040 (Unupgraded Scenario)	~104-133	35%-40%	~36-53	~47-69	The number of ship calls will increase; peak load management through scheduling and flexible berthing capacity will be required.

Table 2 Service Invocation Demand The above calculation indicates that the recent regular service demand in the service area is approximately 32 trips per day, and the peak can reach about 41 trips per day. The regular service demand for the long-term upgrade scenario is approximately 27 voyages per day, with a peak of about 35 voyages per day. Service demand may increase significantly in scenarios where the upgrade is not complete. The recommended plan should adopt a combined strategy of "short-term operational capacity meeting 1,000 tons of high-frequency services, long-term engineering scale meeting 2,000 tons of low-frequency and high-intensity services, and retaining the conditions for flexible expansion in scenarios that have not been fully upgraded".

3.3 Berth Scale Matching Argumentation

Table 3. Berth Capacity Matching Verification Table

Verification Items	Recent Period2035	Long-Term (2040) Upgrade Scenario	Conclusion
Daily average service demand (voyages/day)	31.8	26.7	Recent period represents normal operating conditions
Peak service demand (voyages/day)	41.4	34.7	Peak demand relies on dispatching, reservation systems, and supplementary berthing areas
6 Normal berth service capacity (voyages/day)	31.7	31.7	Insufficient margin in the recent period
Upstream/downstream supplementary berthing capacity	2-4vessels simultaneously berthed	2-4vessels simultaneously berthed	used for peak shaving and short-term queuing, not as long-term berthing capacity
Long-term flexible measures	Reservation-based dispatching, off-peak services, functional reuse, mobile berth contingency plans	expansion of service equipment, activation of 2,000-ton-class berths	conversion to mobile berths to address temporary peaks or in incomplete upgrade scenarios

The berth service capacity is estimated based on 6 service berths as shown in Table 3. During the planning stage, an average service time of 2.5 hours per vessel is taken. Considering factors such as non-continuous full-load operation of service berths, changing berths, security checks, cleaning, emergency redundancy, and night organization, the berth utilization rate is set at 0.55. Based on the calculation of "number of berths×24 hours×utilization rate/average service time", the average daily service capacity of the 6 berths is approximately 31.7 vessels per day. This capacity is almost on par with the recent average daily service demand of 31.8 vessels per day, and the safety margin is insufficient. The peak service demand of 41.4 vessel trips per day is significantly higher than the normal capacity of 6 berths. It is necessary to rely on appointment scheduling, service time compression, function reuse and peak shaving organization while waiting for berths.

To avoid the conclusion on the capacity of 6 berths being too rigid, this study added a service time and utilization sensitivity check (Table 4).

The calculation results show that under optimistic organizational conditions, the capacity of 6 berths can reach approximately 39.3 vessel trips per day, but under less favorable conditions, it is only about 24.0 vessel trips per day. This indicates that the number of berths is not the only controlling factor; operational organization, service processes, and contingency plans for mobile berths are equally crucial. Therefore, the conclusion that the six service berths in the recommended plan are "basically matched under normal conditions but have no margin, and there is a gap at peak times" should be regarded as a rigid constraint for operation scheduling.

Table 4. Service Hours and Berth Utilization Sensitivity Verification

Scenario	average service time	Berth utilization rate	6 Berth service capacity	suitability assessment
Optimistic	2.2h	0.60	39.3 vessels/day	Depend High-efficiency booking systems, rapid replenishment, and continuous service
Benchmark	2.5h	0.55	31.7vessels/day	This level is essentially consistent with recent normal demand, but the margin is insufficient
Unfavorable	3.0h	0.50	24.0vessels/day	Requires significant enhancement of scheduling capabilities or additional flexible service capacity

Based on the above analysis, during the operation period, a reservation service and berth dispatching system should be established, clearly defining the priorities of refueling and gas filling, pollutant reception, shore power replenishment, emergency maintenance and waiting berthing functions. If subsequent operation statistics show that the service invocation ratio exceeds 35%, the average service time exceeds 2.5 hours, or the peak duration is relatively long. It may be considered to set up mobile service berths, or to expand service capacity by utilizing the reserved land on the west bank and the conditions of the upstream and downstream shoreines.

4. Construction Plan Comparison

4.1 West Bank Comprehensive Ecological Service Area Plan

The West Bank plan is located in the wetland and undeveloped area downstream of Shushan Lock, with a planned land use of approximately 100 mu. Based on the initial assessment of image measurement and land use conditions, there is approximately 137 mu of space available for overall utilization on the west bank, and the west side of the site still has ample long-term expansion conditions. Six service berths are arranged along the straight shoreline in the water area, occupying approximately 625 meters of shoreline in total. The wharf adopts a high-pile beam-slab structure, with a platform width of 12 meters and an area of about 7,500 square meters. The wharf structure is reserved for a 2,000-ton class, and the operation will be organized for a 1,000-ton class in the near future. The land area is divided into five functional zones: Energy and Environmental Protection Service Area (15 mu, including diesel /LNG storage tank reservation, sewage pretreatment station, solid waste and hazardous waste temporary storage facilities), Crew Comprehensive Service Area (12 mu, including comprehensive service building and dispatch center), Logistics and Emergency Support Area (18 mu, including supply warehouse, maintenance room, emergency material warehouse), Ecological Buffer and Crew Rest Area (25 mu) It includes wetland restoration, ecological walkways, and landscape water systems, as well as reserved development areas (30 mu, for the expansion of new energy and future functional improvement).

The main advantages of this plan lie in: relatively complete land use, high freedom in spatial organization, few conflicts with existing buildings, and the ability to reserve the structure and the front water area at one time for a 2,000-ton scale, avoiding repeated renovations in the future. Its core positioning is a high-quality water-based comprehensive service area featuring "integrated services + green energy + environmental protection reception + intelligent dispatching + ecological buffering". The main constraints are the large amount of work involved in the treatment of soft soil foundations, wetland ecological protection, the connection of flood control and drainage systems, and the coordination of new construction procedures. The estimated total investment is approximately RMB 239 million.

4.2 East Bank Logistics Collaborative Service Area Plan

The East Bank plan is located on the former site of the No. 1 operation area of the former Yuyao East Port and the vacant land to the south, with a planned land area of approximately 100 mu. Three shore service berths are arranged in the water area, and the wharf structure is reserved for a 2,000-ton class. The land area focuses on the functions of "logistics coordination, industrial expansion, maintenance support and temporary storage", and sets up approximately 35,000 square meters of temporary storage yards and warehousing and distribution facilities. This plan strips away the integrated service facilities that overlap with those on the west bank, eliminates the oil and gas refueling system, and adopts a mobile pollutant receiving method. The basic shore power is connected from the existing power grid on the west bank or in the port area.

The main advantages of this plan lie in its high economic investment (approximately RMB 108 million), significant synergy with existing logistics parks, and simple and efficient transportation organization. The main limitations are as follows: The effective water surface width of the river is approximately 120 meters. At the same position on the east and west banks, berthing cannot be done simultaneously, and peak shaving dispatching must be implemented. Its own service function has weakened, and energy supply and centralized treatment of pollutants are completely dependent on the west bank. The utilization of the old wharf structure is uncertain. A special inspection is required before a reinforcement or demolition plan can be determined.

4.3 Comprehensive Comparison and Recommendation Opinions

A comprehensive comparison was made from the dimensions of functional integrity, berth scale, land use conditions, navigation safety, safety and environmental protection, investment economy, and long-term development capacity (Table 5). The West Coast plan has significant advantages in service capacity, long-term flexibility, and functional integration, and is recommended as the priority implementation plan for the first phase. The east bank plan, as a long-term expansion plan for the second phase, shares the water area with the first phase, achieving coordinated and rolling development of the functions of both banks.

Table 5. Comprehensive Comparison of the Construction Plans for the East and West Coasts

Comparison Dimension	West Coast Scheme (Phase I)	East Coast Scheme (Phase II)
Number of berths	6 (with capacity reserved for 2,000-ton vessels)	3 (with capacity reserved for 2,000-ton vessels)
Planned land area	100 mu (expandable to 137 mu)	100 mu (approximately 9 mu remaining)
Core positioning	Comprehensive services + Green energy + Ecological integration	Logistics synergy + Industrial expansion + Maintenance and support
Terminal structure	High-pile beam-and-slab system (new construction)	Existing terminal reinforcement + new high-pile section
Total investment	RMB 239 million	RMB 108 million
Recommendation rating	★★★★★(Recommended)	★★★(Alternative option for expansion)

The main reasons for recommending the west bank plan are as follows: First, it has a higher degree of alignment with the medium and long-term development positioning of Yuyao Port Area. The layout of six berths is superior to the east bank plan with three berths in terms of average daily service demand, peak dispatching and emergency reserve. Second, it has better engineering adaptability between the recent 1,000-ton class operation and the long-term 2,000-ton class upgrade, which can avoid repetitive construction due to ship type upgrades in the long term. Third, the land use is complete, and the conditions for safety, environmental protection and overall layout are better. Functions such as oil and gas refueling, pollutant reception and crew services can be clearly zoned within the same site. Fourth, it has approximately 37 mu of reserved space, providing greater long-term flexibility. The main issues of the west bank plan (soft foundation treatment, flood control and drainage, and wetland ecological protection) are all problems that can be solved through investigation, special topic argumentation and engineering measures, while the structural state of the old wharf and the safety distance issue of the east bank plan are more uncertain. In terms of phased implementation, the first phase prioritizes the construction of hydraulic structures, front-end dredging, core energy and environmental protection services, and the main body of the comprehensive service building, with an investment of approximately RMB193 million. The second phase will implement ecological landscape improvement, expansion of the new energy system and improvement of warehousing functions in a rolling manner based on operational data, with an investment of approximately RMB 46 million.

5. Conclusions and Suggestions

This paper takes the anchoring service area of Yuyao Port on the Hangzhou-Ningbo Canal as a case study to systematically study the functional positioning, volume matching and construction scheme comparison of inland waterway service areas.

The main conclusions are as follows:

First, the planning of inland waterway service areas should establish a three-level functional system of "basic - enhanced - reserved for the future", and adopt a phased ship type strategy of "short-term operation and reserved for the future" to avoid redundant construction due to ship type upgrades. The newly released "Service Specifications for Inland Waterway Water Service Areas" (JT/T 1583-2026) provides a standard basis for the hierarchical configuration of service functions.

Second, the analysis of volume matching should be carried out from three levels: TEU conversion, service invocation ratio, and berth capacity verification, to clearly define the operational boundaries of service capacity. The conclusion of the 6-berth scheme that "it is basically matched under normal conditions but has no margin, and there is a gap at peak times" should be regarded as a rigid constraint for operation scheduling. Sensitivity checks indicate that the number of berths is not the only controlling factor; operational organization, service processes, and contingency plans for mobile berths are equally crucial.

Thirdly, the selection of construction plans should comprehensively consider functional integrity, land use conditions, safety and environmental protection, as well as investment economy. The West Bank Comprehensive Ecological Service Area has comprehensive advantages in terms of service capacity, long-term flexibility and functional integration, and can be regarded as a priority implementation plan. The east coast plan can play a role in functional complementation and logistics coordination, forming a rolling development pattern of bilateral coordination.

At present, the construction of inland waterway water service areas across the country is in a policy window period. It is suggested that subsequent research be deepened in the following directions: the reasonable spacing and functional configuration standards of water service areas for different grades of waterways; Appropriate scale and economic assessment of green energy replenishment facilities (LNG, shore power, charging) Development of a smart operation and management platform for water service areas Based on intelligent monitoring and digital twin technology And the empirical application of the green evaluation index system for water service areas.

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