

# Research on the High-Quality Development Paths of Zhejiang Canals from the Perspective of Chinese Modernization

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## Abstract

This paper systematically reviews the historical evolution, cultural value, ecological governance, modernization development and institutional innovation of Zhejiang canals, and comprehensively analyzes their innovative practices and strategic paths in the context of the new era. As an important part of China's Grand Canal, Zhejiang canals have evolved from military use and grain transportation lifelines to modern comprehensive transportation systems over the long course of history. In the New Era, driven by multiple strategies such as ecological civilization, smart shipping, cultural-tourism integration, and regional coordination, Zhejiang has taken the lead nationwide in green transformation and digital shipping, promoting the "zero-carbon port" pilot project and building the "shipping brain" platform. Zhejiang has become the first province in China to achieve ecological governance benchmarks for inland shipping and the first pilot province for digital transformation of inland shipping. Zhejiang canals have transformed from traditional shipping channels to "economy-ecology-culture-governance" composite corridors. This paper proposes and constructs a new "Chinese-style modernization canal development model", Zhejiang canals should actively integrate into the new "dual circulation" development pattern, build a world-class modern inland shipping system, promote the activation and utilization of cultural heritage, construct green ecological demonstration corridors, deepen digitalization and smart governance, and explore innovative paths in institutional mechanisms and regional coordination. In the future, Zhejiang canals will play a leading role in the restructuring of the global water transport landscape and become a model for the construction of a Chinese-style modern water transport system.

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## Keywords

Zhejiang Canals, Low-Carbon Transportation, Cultural Heritage, Intelligent Port and Shipping, Green Development, Chinese-Style Modernization Canal Development Model

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## 1. Introduction

In a narrow sense, Zhejiang canals specifically refer to the Zhejiang section of the Beijing-Hangzhou Grand Canal, which is an important component of the southern end of China's Grand Canal. It flows through Hangzhou, Jiaxing, Huzhou and other areas, with a total length of about 120 kilometers. Historically, it was a hub for southern grain transportation and still preserves cultural heritage sites such as the Gongchen Bridge and Guangji Bridge. In a broad sense, it encompasses all artificially excavated canal systems in Zhejiang that connect with natural rivers, including the Zhejiang East Canal (Hangzhou-Ningbo Canal), a thousand-year-old waterway connecting Hangzhou and Ningbo, as well as canal network systems such as the Jiangnan Canal's Jiaxing-Hangzhou section and Nanxun section. These canals not only connect natural water systems such as the Qiantang River, Cao'e River, and Yao River, but also form a water transport network that links rivers to the sea, serving multiple functions including shipping, irrigation, and ecology. They are an important carrier of Zhejiang's water culture [1].

As an important part of China's Grand Canal, Zhejiang canals carry rich historical and cultural connotations and have played a significant role in regional economic development. In recent years, with the advancement of the Grand Canal Cultural Belt construction, research on Zhejiang canals has become a hot topic in academic circles. The history of Zhejiang canals can be traced back to the late Spring and Autumn period, when the states of Wu and Yue excavated canals for military purposes, forming an early water transport network [2]-[4]. Zhang M. & Li J. point out that Wu's "Baichi Du" and Yue's "Shanyin Ancient Waterway" became the prototypes of the Zhejiang West Canal and Zhejiang East Canal respectively [5]. The dredging of the "Lingshui Dao" during the Qin Dynasty further connected the Wu-Yue waterway network, laying the foundation for the development of Zhejiang canals. During the Sui and Tang dynasties, Zhejiang canals were incorporated into the national grain transportation system, significantly elevating their status. Wang C. & Chen S. emphasize that after the Southern Song Dynasty established its capital in Lin'an (modern Hangzhou), the Zhejiang East Canal became an important channel connecting the capital with the Mingzhou Port (modern Ningbo), promoting regional economic prosperity and cultural exchange [6]. During the Yuan, Ming, and Qing dynasties, the Zhejiang West Canal, as the "Southern Grain Corridor" for transporting grain northward, became increasingly prominent. However, in the latter half of the 19th century, with the rise of modern railways and maritime transport, the transportation function of Zhejiang

canals gradually declined [7].

Zhejiang canals are not just transportation channels but also axes of cultural dissemination. Zhao M. & Sun L. note that during the Southern Song Dynasty, scholars of the Zhejiang East School spread their ideas northward along the canal; during the Ming Dynasty, Yangming's philosophy of mind radiated nationwide through the canal; and during the Qing Dynasty, the rise of the Ci School in Western Zhejiang and the historiography in Eastern Zhejiang during the Qing Dynasty also benefited from the convenience of water transportation provided by canals [8]. Academies and libraries along the canal, such as Fuwen Academy in Hangzhou and Tianyi Pavilion in Ningbo, became important nodes for academic exchange. In 2014, China's Grand Canal was successfully inscribed on the World Heritage List, marking a new phase in the cultural heritage protection of Zhejiang canals. Wang C. & Chen S. emphasize that ancient towns, bridges, and hydraulic facilities along the Zhejiang West Canal, such as Tangqi Ancient Town, Changhong Bridge, and Chang'an Sluice, have become the core content of cultural heritage protection [7].

The ecological governance of Zhejiang canals is key to achieving their sustainable development. Lin Z. & Zheng Y. propose that the ecological governance of Zhejiang canals should follow the concept that "*lucid waters and lush mountains are invaluable assets*," implementing comprehensive water environment management to improve canal water quality and ecological functions [9]. In recent years, pollution control and ecological restoration along Zhejiang canals have achieved remarkable results, transforming them into urban waterfront landscapes and becoming tourist and leisure routes where people can enjoy boating and beautiful scenery. Additionally, the sustainable development of Zhejiang canals requires attention to the construction of a modern shipping system. Liu H. & Wu X. point out that since the 21st century, the modernization of Zhejiang canals has accelerated, with continuous upgrades to the Hang-Jia-Hu waterway network [7]. The Zhejiang section of the Beijing-Hangzhou Canal has become a national-level model civilized waterway. By improving waterway standards and navigation capacity and developing multimodal transport, Zhejiang canals continue to play a pivotal role in regional logistics and transportation systems.

The modernization of Zhejiang canals is an important way for them to regain vitality in the New Era. Liu H. & Wu X. emphasize that the modernization of Zhejiang canals includes not only waterway upgrades and facility improvements but also innovations in management models [7]. For example, after renovation and upgrading, the Hangzhou-Ningbo Canal can accommodate 500-ton ships, achieving "river-sea intermodal transport" and becoming an important channel for inland goods to reach the sea. Wang C. & Chen S. note that the modernization of Zhejiang canals is also reflected in the integration of culture and tourism and urban renewal [6]. Areas along the river in Hangzhou, Jiaxing, Huzhou, and other places have successively carried out pollution control and ecological restoration, transforming into urban waterfront landscapes and opening water bus and cul-

tural tourism projects, becoming tourist and leisure routes where people can enjoy boating and beautiful scenery. The evolution of Zhejiang canals is an epic of harmonious coexistence between humans and nature and a testament to the continuous development of regional civilization through openness. From initial excavation in ancient times to prosperous development in early modern times, and then to modernization after the founding of the People's Republic of China, Zhejiang canals have always carried the original intention of "connecting rivers to the sea and benefiting the people" [10]-[13].

This study employs a mixed-methods approach combining on-site visits to local (prefecture-level city) inland waterway transportation management authorities, research at canal museums (exhibition halls), systematic literature analysis, policy text interpretation, and expert consultations to construct a "China's Modernized Canal Development Model." Researchers conducted fieldwork in cities including Hangzhou, Ningbo, Wenzhou, Shaoxing, Jiaxing, Huzhou, Lishui, and Quzhou. The literature selection focused on domestic and international studies published since 2010 concerning the modernization of inland waterway transportation, green and low-carbon transitions, cultural heritage preservation, smart port and shipping systems, and regional collaborative governance, with priority given to empirically supported publications. During model construction, a multi-dimensional perspective was adopted, integrating considerations of policy orientation, technological applications, ecological benefits, and cultural preservation. Key data sources included annual reports, newsletters, and statistical publications from the Zhejiang Provincial Bureau of Statistics, Zhejiang Provincial Department of Transport, and Zhejiang Provincial Port and Shipping Administration Center.

## **2. Historical Achievements in the Construction and Development of Zhejiang Canals**

As an important part of China's Grand Canal, Zhejiang canals are not only an artery connecting ancient and modern times but also a living witness to the thousand-year inheritance of Chinese civilization. In the long course of historical evolution, Zhejiang canals have continuously renewed their vitality with the geographical advantage of "connecting rivers to the sea" and the governance wisdom of "benefiting the people." From an ancient lifeline for grain transportation to a modern ecological and cultural corridor, the construction and development of Zhejiang canals embody national will, regional mission, and cultural confidence, becoming a pioneering demonstration for the construction of a Chinese-style modern water transport system in the New Era.

### **2.1. Waterway Upgrades and Shipping Revival: From Ancient Grain Transportation to Modern River-Sea Intermodal Transport**

The waterway construction of Zhejiang canals has undergone a leapfrog development from ancient manual excavation to modern high-standard waterways. From

the “Baichi Du” and “Shanyin Ancient Waterway” during the Wu-Yue period to the connection of the “Lingshui Dao” during the Qin and Han dynasties, the canals laid the skeleton for southern grain transportation. From the Sui and Tang dynasties to the Song and Yuan dynasties, with the establishment of the national grain transportation system, Zhejiang canals became the core channel for “transporting grain from the south to the north.” Entering the 21st century, Zhejiang has vigorously promoted the modernization of waterways. The second channel of the Beijing-Hangzhou Canal was completed and put into use in 2023, and after renovation, the Hangzhou-Ningbo Canal can accommodate 500-ton ships, achieving “river-sea intermodal transport,” connecting inland areas to the sea, and injecting new momentum into the regional logistics system.

## **2.2. Cultural Heritage Activation and Cultural Confidence: From Hydraulic Relics to World Heritage**

Zhejiang canals are not just a water transportation line but also a cultural axis spanning thousands of years. Hydraulic relics along the route, such as Gongchen Bridge, Guangji Bridge, and Chang’an Sluice, witness the brilliance of ancient engineering wisdom; cultural landmarks such as Fuwen Academy and Tianyi Pavilion record the trajectory of ideological dissemination and academic inheritance. In 2014, China’s Grand Canal was successfully inscribed on the World Heritage List, with the Zhejiang section becoming a model for cultural protection and activation. Through legislative protection, digital empowerment, and cultural-tourism integration, the cultural heritage of Zhejiang canals is returning to public life in a living way, becoming an important carrier for enhancing cultural confidence and telling China’s stories well.

## **2.3. Regional Economic Coordination and Port Linkage: From Inland Water Transport to National Strategic Channel**

As the core hub of the water transport network south of the Yangtze River, the economic function of Zhejiang canals has continuously evolved in different historical stages. From the “lifeline of grain transportation” in the Song Dynasty to the “artery of commerce” in the Ming and Qing dynasties, and then to “multi-modal transport” in contemporary times, the canals have always resonated with regional development. The Hangzhou-Jiaxing-Huzhou canal network forms an efficient linkage with Ningbo-Zhoushan Port, and the Hangzhou-Ningbo Canal achieves “river-sea intermodal transport,” promoting Zhejiang as a logistics hub connecting inland areas to the sea. This water transport system not only serves the Yangtze River Delta integration strategy but also becomes a key channel for inland goods to reach the sea under the “Belt and Road” initiative, supporting high-quality coordinated regional economic development.

## **2.4. Ecological Governance and Green Development: From Pollution Control to Ecological Civilization Demonstration**

Facing ecological and environmental challenges, Zhejiang canals have taken the

lead in practicing the concept that “lucid waters and lush mountains are invaluable assets,” forging a new path of ecological priority in governance. Through systematic projects such as river dredging, wetland restoration, shoreline greening, and pollution control, the water quality of the canals has significantly improved, and ecological functions have gradually been restored. Green waterway demonstration projects such as the Huzhou section of the Hu-Jia-Shen Line have become models for national inland ecological governance. At the same time, Zhejiang has deeply integrated canal governance with rural revitalization and common prosperity, creating a new paradigm of “waterfront linkage” for ecological shared prosperity, providing Zhejiang’s experience in green transformation for the nation.

### **2.5. Institutional Innovation and Governance Modernization: From Local Governance to Smart Shipping Pioneer Area**

The governance of Zhejiang canals has always been at the forefront of the nation, forming a governance evolution path from ancient “joint governance by officials and the people” to modern “digital empowerment.” The establishment of the Zhejiang Provincial Port and Shipping Management Center marks a new stage of systematic, professional, and digital water transport governance. Through digital means such as the “shipping brain” platform, electronic waterway maps, and intelligent dispatching systems, comprehensive supervision and efficient dispatching of waterways, ships, and logistics have been achieved. At the same time, credit supervision, policy guidance, and market mechanisms work together to promote the governance system’s leap from “experience-driven” to “data-driven,” providing institutional innovation samples for Chinese-style modern water transport governance.

## **3. Innovative Practices in the Construction and Development of Zhejiang Canals in the New Era**

In the New Era, the development of Zhejiang canals has not only focused on modernization, green transformation, and digital empowerment, but has also actively integrated into the broader national strategy of water transport restructuring and regional coordination. Zhejiang’s canals have formed synergistic linkages with major waterway projects such as the Guangxi Pinglu Canal, Hunan-Xianggui Canal, Jiangxi Zhe-Gan-Yue Canal, and the southern Jiangsu section of the Beijing-Hangzhou Grand Canal. Together, they are shaping a modern inland waterway system that embodies the national vision of “river-sea synergy and integrated water-land coordination.” During this process, Zhejiang canals have demonstrated unique geographical advantages, historical depth, and institutional innovation, becoming a crucial node in advancing the construction of a Chinese-style modern waterway system.

### **3.1. Enhancement of Waterway Hub Status: From “Regional Artery” to “National Channel”**

As a core node in the southern Yangtze River waterway network, Zhejiang canals,

together with the Guangxi Pinglu Canal, Jiangxi Zhe-Gan-Yue Canal, and Hunan Xianggui Canal, are forming a new waterway pattern characterized by “east-west coordination and north-south connectivity.” The Guangxi Pinglu Canal, a key component of the new western land-sea corridor, spans 134.2 kilometers and involves a total investment of 72.7 billion yuan. Upon completion, it will enable the passage of 5000-ton vessels, significantly reducing the distance for Guangxi goods to reach the sea (by over 560 kilometers), thus boosting the economic vitality of the Beibu Gulf region. In comparison, while Zhejiang canals primarily accommodate medium-sized vessels, their efficient interconnection with Ningbo-Zhoushan Port via the Hangzhou-Ningbo Canal has enabled regular operations of river-sea intermodal transport, providing strong port synergies. Meanwhile, the Jiangxi Zhe-Gan-Yue Canal, with over 800 billion yuan planned for development during the 14th and 15th Five-Year Plans, aims to establish a direct water connection between the Yangtze River Delta and the Pearl River Delta, promoting deeper integration between Jiangxi’s inland hinterlands and coastal economic zones. Within this framework, Zhejiang canals play a pivotal hub role, connecting eastward to Ningbo-Zhoushan Port, northward to the Yangtze River, and southward to Fujian and Guangdong, serving as a key link for “river-sea intermodal transport and sea-river interaction.” Additionally, the Hunan Xianggui Canal is designed to open a major north-south waterway connecting the upper and middle reaches of the Yangtze River with the Beibu Gulf, shortening transport distances by approximately 1200 kilometers and providing new logistics pathways for China’s central and western provinces to access international markets in ASEAN and Europe. Zhejiang canals, through seamless integration with the Hangzhou-Ningbo Canal and Ningbo seaport, offer an efficient maritime outlet for export goods from Hunan and Jiangxi, forming a complete “inland waterway-port-ocean” supply chain system.

### **3.2. Channel Upgrades and Enhanced Navigation Capacity: Benchmarking with Jiangsu’s Southern Canal Modernization Project**

In recent years, Zhejiang has vigorously upgraded its waterway infrastructure. The second channel of the Beijing-Hangzhou Grand Canal (Hangzhou section) was completed and put into operation in 2023, effectively alleviating congestion on traditional routes and enabling the passage of thousand-ton vessels. After the renovation of the Hangzhou-Ningbo Canal, 500-ton ships can now directly reach Ningbo-Zhoushan Port, marking a new era of river-sea intermodal transport. Concurrently, Jiangsu is advancing the modernization of the southern section of the Beijing-Hangzhou Canal, increasing its capacity from 1000 to 2000 tons, effectively creating a “new southern Jiangsu Canal.” This upgrade significantly enhances the waterborne freight capacity of eastern and central Yangtze River Delta regions. In contrast, Zhejiang’s approach to canal modernization emphasizes the synergistic development of multimodal transport and green shipping, focusing on seamless integration with port, rail, and road transport networks to optimize the

overall transportation system. While Zhejiang's canals have not yet reached the 2000-ton capacity, they lead the nation in terms of navigation efficiency, informatization, and environmental friendliness. Through digital platforms such as the "Shipping Brain" system, real-time vessel monitoring and intelligent dispatching have improved traffic efficiency by over 25% and reduced accident rates by 40%, highlighting Zhejiang's leadership in smart shipping.

### **3.3. Green Transformation and Ecological Governance: Building a "Zero-Carbon Waterway" Demonstration Corridor**

Zhejiang canals have taken a national lead in green transformation by constructing green waterway demonstration sections (e.g., the Huzhou section of the Hu-Jia-Shen Line), promoting shore power facilities, and implementing pollution control measures for vessels. As a result, carbon emission intensity has decreased by 45% compared to 2015. Moreover, Zhejiang actively promotes pilot projects for "zero-carbon ports," exploring clean energy substitution and carbon compensation mechanisms, establishing itself as the first province in China to achieve ecological governance benchmarks for inland shipping. The Guangxi Pinglu Canal, from its inception, has emphasized "ecological priority and green development," focusing on ecological restoration and water resource protection. Similarly, the Jiangxi Zhe-Gan-Yue Canal advocates for "green waterways and low-carbon transport." However, Zhejiang canals have advanced to a stage of "refined and systematic" ecological governance, going beyond pollution control to include waterfront coordination, wetland restoration, and ecological landscape construction. This has transformed canals from mere transport channels into ecological corridors. Furthermore, Zhejiang creatively integrates historical water management practices into modern governance. For example, using natural water systems such as West Lake and Jianhu Lake to optimize water resource allocation enhances flood control and irrigation functions. This integrated "ecology + culture + shipping" model provides a replicable green waterway template for the nation.

### **3.4. Integration of Culture, Tourism, and Heritage Preservation: From "Water Corridor" to "Cultural Artery"**

Zhejiang canals, rich in historical and cultural heritage, have undergone a functional transformation from transport channels to cultural axes through legislative protection, ecological restoration, and digital empowerment. The promulgation of the \*Zhejiang Grand Canal World Cultural Heritage Protection Regulation\* marks Zhejiang as the first province in China to legislate for Grand Canal heritage protection. Historic towns such as Wuzhen and Nanxun have adopted innovative digital displays and AR/VR night tours, attracting over 10 million tourists annually and stimulating local cultural and tourism economies. In contrast, canal projects in Guangxi, Hunan, and Jiangxi are still in the planning or construction phase, with cultural resource development and tourism integration at an early stage. For example, the historical and cultural resources along the Pinglu Canal

remain unorganized, and tourism development requires further accumulation. However, Zhejiang's "Poetic Canal Route" cultural belt and the "Canal+" industrial model have formed a brand effect, becoming a key vehicle for regional cultural soft power. Although Jiangsu's southern section of the Beijing-Hangzhou Canal has also proposed to build a "Canal Cultural Corridor," Zhejiang demonstrates greater systematic and innovation in cultural activation and industrial integration. Through tools such as the "Canal Cloud Travel" mini-program, digital heritage archives, and blockchain copyright management, Zhejiang has achieved digital dissemination and value transformation of cultural resources, driving the cultural and tourism industry toward high-quality and intelligent development.

### **3.5. Digital Empowerment and Governance Innovation: Constructing a New Ecosystem of "Intelligent Ports and Shipping"**

Zhejiang leads the nation in digital port and shipping development, having established the "Shipping Brain" platform, which enables real-time vessel monitoring, full coverage of electronic navigation maps, and integrated intelligent dispatching and emergency response. It has also piloted autonomous ships and 5G Internet of Things (IoT) applications, making Zhejiang the first province in China to conduct digital transformation pilots for inland shipping. While waterway projects in Guangxi, Jiangxi, and Hunan have also proposed "smart waterway" goals, they are still in the early stages regarding infrastructure, data integration, and platform construction. For instance, although the Pinglu Canal emphasizes "digital twin" and "smart management," it has not yet established a systematic digital governance framework. Zhejiang's advantage lies in its three-pronged approach combining policy, technology, and mechanism innovation. Through the "credit plus regulation" mechanism, it has optimized the business environment, with a 50% improvement in administrative approval efficiency, attracting international shipping enterprises to establish operations in the province. In 2024 alone, Zhejiang saw over 20 billion yuan in new port and shipping investments. Additionally, Zhejiang is advancing the "One-Stop Multimodal Transport" platform, reducing enterprise logistics costs by 15% and achieving an 18% annual growth in rail-water intermodal transport volume, significantly enhancing regional logistics efficiency.

### **3.6. Regional Collaboration and International Engagement: From "Provincial Channel" to "International Hub"**

Zhejiang canals serve not only regional economic development but also actively integrate into major national strategies, becoming key supports for the Belt and Road Initiative, the Yangtze River Delta Integration Strategy, and the construction of the Common Prosperity Demonstration Zone. The Hangzhou-Ningbo Canal connects to Ningbo-Zhoushan Port, serving as a vital channel for inland goods to access the sea and reinforcing Zhejiang's position in the global supply chain. The Guangxi Pinglu Canal serves as a key maritime channel linking China with ASEAN,

Africa, and other Belt and Road countries. The Jiangxi Zhe-Gan-Yue Canal will enhance Jiangxi's openness to the Greater Bay Area, while the Hunan Xianggui Canal strengthens the international logistics capabilities of central provinces. Against this backdrop, Zhejiang canals collaborate with canal projects in other provinces to form a national waterway network characterized by "east-west coordination, north-south connectivity, and land-sea integration." Zhejiang also actively participates in the formulation of international standards and exports its "river-sea intermodal transport" experience to regions such as ASEAN and Africa, enhancing its voice in global shipping rule-making and promoting the internationalization of Chinese waterway technology and services.

#### **4. Construction of Chinese-Style Modern Canal Development Model**

As China's economy has transitioned from a stage of high-speed growth to one of high-quality development, the comprehensive advancement of Chinese-style modernization presents unprecedented strategic opportunities for the transformation and upgrading of Zhejiang canals. As a demonstration zone for common prosperity and a key node in the construction of the Grand Canal Cultural Belt, Zhejiang's canal system is not only the lifeline of regional socio-economic development but also a "pilot zone" and "window" for the construction of a Chinese-style modern waterway system. In the face of global trends in green transformation, the digital revolution, and regional coordination, Zhejiang canals should base their development on China's national conditions while embracing the world, guided by the strategic objectives of modernization, ecological integration, cultural revitalization, and digital empowerment. This paper proposes to comprehensively construct a "Chinese-style modern canal development model" to facilitate the transformation from traditional water transport channels to comprehensive corridors integrating "economy-ecology-culture-governance", creating a globally influential Chinese-style modern water transport exemplar. The Chinese-style modern canal development model encompasses the following five aspects:

##### **4.1. Strengthening Canal Economy to Advance Modern Shipping**

In the economic dimension of Zhejiang's canals, aims to promote the construction of a world-class modern inland waterway system and create a "dual circulation" water transport hub. In the context of a deeply reshaped global trade landscape, Zhejiang canals should proactively integrate into the new development pattern of "dual circulation" (domestic and international cycles) by constructing a modern inland shipping system with international competitiveness and strengthening the hub function of "river-sea intermodal transport." First, accelerate the expansion of waterway capacity and multimodal transport upgrades. Key projects such as the second channel of the Beijing-Hangzhou Canal should be prioritized to enhance the Hangzhou-Jiaxing-Huzhou waterway system, enabling regular navigation of

1000-ton ships. Leveraging the seamless connection between the Hangzhou-Ningbo Canal and the Ningbo-Zhoushan Port, an efficient integrated waterway-port-ocean channel should be developed to serve the Belt and Road Initiative and RCEP regional cooperation. Second, build a multimodal transport network integrating road, rail, and water transport. Optimize the port collection and distribution system to ensure efficient intermodal connectivity at key transport nodes. Through information sharing and process reengineering, logistics efficiency should be increased and the overall transportation costs for enterprises reduced, reinforcing Zhejiang's pivotal role in both domestic and international dual circulation. Third, promote green and low-carbon shipping development. Popularize new energy-powered vessels, establish green waterway demonstration sections (e.g., the Huzhou section of the Hu-Jia-Shen Line), promote shore power facilities, implement pollution control for vessels, and explore pilot projects for "zero-carbon ports." In alignment with the goals of carbon peaking and carbon neutrality, construct a tripartite green shipping system integrating clean energy substitution, carbon sink compensation, and green finance, positioning Zhejiang as a national model for green inland waterway transformation.

#### **4.2. Inheriting Canal Culture to Shape a Cultural Highland**

In the cultural dimension of Zhejiang's canals, will deepen the protection of cultural heritage and the integration of culture and tourism to shape a global canal cultural highland. Zhejiang canals are important carriers of Chinese civilization. Their cultural value is not only reflected in historical heritage but also in their modern roles as channels for cultural dissemination, intellectual exchange, and urban memory. Against the backdrop of increasing global competition for cultural soft power, Zhejiang should lead with culture and leverage technology to revitalize and globally promote its canal cultural resources. First, implement a project for the living inheritance of cultural heritage. Based on the Zhejiang Grand Canal World Cultural Heritage Protection Regulation, strengthen the systematic protection of material heritage such as ancient towns, bridges, hydraulic facilities, and post roads. Promote digital upgrading of 5A-level scenic spots like Wuzhen and Nanxun, and build a heritage display system combining "digital twins" and "immersive experiences." Second, build a world-class cultural and tourism brand for canals. Relying on the "Poetic Canal Route" cultural belt, develop thematic educational routes such as Song Dynasty culture, Yangming's philosophy of mind, Zhejiang East historiography, and academy culture. Drawing on the experience of the Asian Games, expand AR/VR night tours (e.g., "Tanghe Night Painting") to enhance cultural immersion and tourist experience. Third, cultivate new forms of "canal+" industries. Promote diversified integration through "canal + cultural creativity," "canal + intangible cultural heritage," "canal + sports," and "canal + exhibitions." Develop distinctive projects such as canal-themed cultural markets, intangible heritage craft experience centers, and water-based marathons, creating

a new cultural consumption scene with international influence.

### **4.3. Governing Canal Ecology to Create Ecological Common Prosperity**

In the ecological dimension of Zhejiang's canals, will promote ecological governance and ecological common prosperity to create a demonstration corridor of "lucid waters and lush mountains". As a "living heritage," the ecological value of Zhejiang canals goes beyond regional water quality—it reflects China's broader ecological civilization. In the face of growing global attention to ecological governance and sustainable development, Zhejiang should deeply integrate canal ecological governance with rural revitalization and common prosperity, creating a replicable and scalable model of "green shared prosperity." First, implement a comprehensive ecological restoration project. Carry out pollution control, dredging, wetland restoration, and shoreline greening along the canal to build an integrated ecological corridor. Drawing on historical practices like "using lakes to regulate canals," optimize the ecological water supply from systems like West Lake and Jian Lake to enhance flood control, irrigation, and ecological regulation functions. Second, construct an ecological shared prosperity mechanism. Integrate canal governance with initiatives such as the "Mountain-Sea Cooperation Project" and "Leapfrog Development for 26 Counties in Mountainous Areas," promoting green industries such as ecological tourism, sports and leisure, and cultural creativity in riverside villages, achieving an organic unity of "ecological beauty" and "people's prosperity." For example, Jieshou Township in Qiandaohu, Hangzhou, has become a model of ecological shared prosperity through the development of aqua-sports industries leveraging Asian Games infrastructure. Third, explore "zero-carbon water transport" and carbon sink trading mechanisms. Pilot carbon-neutral waterway projects in demonstration sections such as the Hu-Jia-Shen Line and the Beijing-Hangzhou Canal, and promote innovations in carbon sink trading, green finance, and ecological compensation, offering a Zhejiang model for the country's green inland waterway transformation.

### **4.4. Enhancing Canal Technology to Lead Digital Intelligence**

In the technological dimension of Zhejiang's canals, will promote digital empowerment and smart governance to build the nation's first "smart port and shipping" demonstration zone. Digitalization is the core driving force of the new round of technological and industrial revolution. Leveraging Zhejiang's foundational advantage in building a "Digital Zhejiang," the province should accelerate the digital transformation of its canals, aiming to establish the first national "Intelligent Port and Shipping" demonstration zone, and shift the governance model from "experience-driven" to "data-driven." First, build a "Digital Waterway" and "Shipping Brain" system. Using technologies such as IoT, 5G, Beidou navigation, and AI, achieve real-time monitoring of water levels, vessel dynamics, and meteorological data to enhance navigation efficiency and safety. Establish a unified port and ship-

ping big data platform that integrates logistics, environmental protection, and meteorological data, enabling intelligent dispatching, precise regulation, and emergency response. Second, develop smart cultural tourism and digital public services. Launch a “Canal Cloud Travel” mini-program to provide virtual tours, intelligent interpretation, and AR navigation, attracting younger tourist demographics. Create a digital archive of cultural heritage, using blockchain technology to protect cultural relic copyrights and confirm digital asset ownership, transforming cultural resources into digital assets. Third, pilot autonomous ships and intelligent ports. Implement autonomous vessel pilots on key sections such as the Hangzhou-Ningbo Canal to explore new models of intelligent shipping. Promote the application of “5G + edge computing” in port loading/unloading and transport scheduling to improve service efficiency and intelligence levels.

#### **4.5. Promoting Canal Governance for Coordinated Regional Development**

In the governance dimension of Zhejiang’s canals, will improve institutional mechanisms and regional coordination to create a global model for water transport governance. Against the backdrop of accelerating restructuring in global waterway governance, Zhejiang should lead with institutional innovation, building an efficient and coordinated governance system, promoting regional collaboration and international cooperation, and enhancing its voice in global waterway rule-making. First, innovate the canal governance system and mechanisms. Strengthen the coordinating role of the Zhejiang Provincial Port and Shipping Management Center, and establish cross-regional, cross-departmental, and cross-level collaborative governance mechanisms to address cross-jurisdictional challenges in waterway planning, ecological restoration, and cultural heritage protection. Explore a multi-investment mechanism combining “government leadership + social participation + market operations,” encouraging enterprises and private capital to invest in canal-related cultural tourism and environmental protection projects. Second, deepen regional coordination and integration into the Yangtze River Delta. Promote coordinated development among canal cities in terms of waterway standards, information platforms, industrial layout, and policy mechanisms, achieving standard mutual recognition, information sharing, and industrial complementarity. Leverage the Grand Canal Cultural Belt to create a Yangtze River Delta demonstration zone integrating “culture-ecology-transport.” Third, expand international exchanges and global cooperation. Utilizing the Belt and Road Initiative, facilitate cooperation between Zhejiang canals and waterway projects in ASEAN, Africa, and Europe, exporting experience in “river-sea intermodal transport”, “green shipping”, and “intelligent port and shipping”. Participate in the formulation of international waterway standards and enhance Zhejiang’s strategic position in the global supply chain through international port cooperation and shipping alliances.

## 5. Conclusions

Zhejiang canals, as an indispensable part of China's Grand Canal system, not only carry profound historical and cultural heritage but also demonstrate vigorous vitality and strategic value in the New Era. Their development reflects a profound transformation in China's inland waterway system—from ancient grain transportation to modern shipping, and from a single transport function to a multi-dimensional integration of ecology, culture, economy, and governance. In the context of the comprehensive promotion of Chinese-style modernization, Zhejiang canals are gradually building a modern inland waterway comprehensive corridor integrating “economy-ecology-culture-governance,” guided by strategic tools such as waterway upgrades, cultural activation, green development, digital empowerment, and institutional innovation.

Looking ahead, Zhejiang canals should deepen strategic collaboration with major national waterway projects such as the Guangxi Pinglu Canal, Jiangxi Zhegan-Yue Canal, and Hunan Xianggui Canal, promoting the formation of a national integrated waterway pattern characterized by “river-sea intermodal transport and water-land coordination.” At the same time, efforts should be accelerated to build intelligent port and shipping system, expand green and low-carbon development pathways, strengthen cultural heritage protection and cultural-tourism integration, and enhance regional governance capabilities and international influence. Through institutional innovation and technological empowerment, Zhejiang canals will not only contribute to regional high-quality development and the construction of a common prosperity demonstration zone, but also provide a replicable and scalable “Zhejiang model” for the construction of a Chinese-style modern waterway system, playing a leading role in the reshaping of the global water transport governance landscape.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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