



Sustainable Development of the Grand Canal Cultural Heritage Ecological Reserve: Policy Framework, Construction Model, Technological Innovation

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Abstract. Digital reform empowers the protection of cultural heritage and helps build a new cultural heritage ecological reserve. Influenced by the Internet of Things, mobile navigation and positioning and artificial intelligence and other new technologies, the protection and inheritance of cultural heritage in the cultural ecological reserve is gradually entering the stage of informationization and networking. Based on the holistic protection of intangible cultural heritage, the Grand Canal Cultural Heritage Ecological Reserve has made use of digital technologies such as laser scanning and three-dimensional modelling, which have comprehensively improved the protection and management capacity and level of the Grand Canal (Zhejiang section) management ability, which in turn promotes the economic development and cultural inheritance of the Cultural Heritage Ecological Reserve. Therefore, this paper takes the construction of the Grand Canal Cultural Heritage Ecological Reserve as the main body, analyses the policy framework, policy content, construction mode, major projects, etc., of the sustainable development of the Cultural Heritage Ecological Reserve, and studies the technological innovations of remote sensing technology, geographic information system, etc., in the Cultural Heritage Ecological Reserve of the Grand Canal, in order to provide a new way of thinking for the sustainable development of the region.

Keywords: Grand Canal Cultural Heritage Ecological Reserve; remote sensing technology; geographical information system; sustainable development; Practical Path

1 Introduction

The Grand Canal Cultural Heritage Ecological Reserve is a provincial-level cultural heritage ecological reserve in Zhejiang Province, which is jointly created by Gongshu District, Yuhang District and Linping District of Hangzhou. On 2 September 2020, the Department of Culture and Tourism of Zhejiang Province announced the list of provincial-level cultural heritage ecological reserves (creation) in Zhejiang Province, and the

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Grand Canal Cultural Heritage Ecological Reserve was selected as a provincial-level cultural heritage ecological reserve (creation). In 2023, the Department of Culture and Tourism of Zhejiang Province Department of Culture and Tourism announced the list of provincial cultural heritage ecological protection zones and formally established the Grand Canal Cultural Heritage Ecological Protection Zone. The Grand Canal Cultural Heritage Ecological Protection Zone adheres to the concept of conservation priority and overall protection, and was established mainly to protect the intangible cultural heritage and natural ecosystems along the Grand Canal. For example, to protect ancient buildings, cultural relics and traditional skills along the Grand Canal; in terms of protecting the ecological environment, it is necessary to limit industrial and agricultural pollution, control land development, and restore and protect natural ecosystems such as wetlands, rivers and lakes, in order to protect the stability of the ecological environment and biodiversity along the Grand Canal.

2 Policy Framework for Sustainable Development of the Grand Canal Cultural Heritage Ecological Reserve

2.1 National policies for the sustainable development of the Grand Canal Cultural Heritage Ecological Reserve.

The construction of cultural eco-sanctuaries in the field of non-heritage conservation has achieved considerable conservation results, demonstrated innovative Chinese experience, and realized the exemplary role of regional cultural conservation practices with Chinese characteristics.¹ In the process of promoting the construction of cultural ecological reserves, the former Ministry of Culture, in response to the unified standardization of work and planning, issued the Guidelines of the Ministry of Culture on Strengthening the Construction of State-level Cultural Ecological Reserves, the Notice of the General Office of the Ministry of Culture on Strengthening the Preparation of the Overall Plan of the State-level Cultural Ecological Reserves in 2010 and 2011, respectively, and in December 2018, the Ministry of Culture and Tourism issued Ministerial Decree No. 1, Administrative Measures for State-level Cultural Ecological Reserves. Based on the concept of cultural eco-reserves towards deep and sustainable development, the Administrative Measures for State-level Cultural Eco-Reserves implements the Law of the People's Republic of China on Intangible Cultural Heritage, promotes the overall regional protection of intangible cultural heritage, and marks the entry of the construction of State-level Cultural Eco-Reserves into a new historical stage, and also marks a higher level of protection of intangible cultural heritage in accordance with the administration of the law and the rules and regulations.

2.2 Zhejiang policies for the sustainable development of the Grand Canal Cultural Heritage Ecological Reserve.

In March 2020, with the consent of the Zhejiang Provincial Government, the Zhejiang Provincial Department of Culture and Tourism issued the Opinions on the Construction

of Provincial-level Cultural Inheritance Ecological Reserves in Zhejiang Province, which implements the Measures for the Management of National-level Cultural Ecological Reserves and guarantees the overall regional protection of intangible cultural heritage in Zhejiang Province. In June 2021, the Development and Reform Commission of Zhejiang Province and the Propaganda Department of the CPC Zhejiang Provincial Party Committee issued the Zhejiang Provincial Development and Reform Commission and the Propaganda Department of the Zhejiang Provincial Party Committee issued the Zhejiang Provincial Cultural Reform and Development "Fourteenth Five-Year Plan", and in the planning of Article 8 "Promoting the Revitalization and Development of Excellent Traditional Culture", "Developing and Constructing a System for Protecting and Transmitting the Intangible Cultural Heritage" and In Article 8 of the Plan, "Promoting the Revitalization and Development of Excellent Traditional Culture", "Developing and Building the Protection and Inheritance System of Intangible Cultural Heritage" and "Promoting the Promotion and Transformation of Traditional Culture" propose the construction of cultural heritage ecological reserves and the acceleration of the construction of cultural ecological reserves at the national and provincial levels. The protection of intangible cultural heritage should adhere to the principle of "simultaneous protection and utilization", and further strengthen the overall protection, revitalization and utilization, and integrated development. For the provincial cultural heritage ecological protection zone, Zhejiang Province emphasized the need to base on the holistic protection of intangible cultural heritage, highlight the regional cultural characteristics, cultivate characteristic industrial clusters through the integration of projects, industries and markets, enhance the capacity of the inheritance and development of outstanding traditional culture, and promote the comprehensive and coordinated development of the local economy, society and culture. Department, Provincial Culture and Tourism Department, and Provincial Party Committee Propaganda Department jointly issued the Implementation Plan for the Protection, Inheritance and Utilization of the Grand Canal Culture in Zhejiang Province. The development plan for the Grand Canal Cultural Heritage and Ecological Protection Zone takes the overall requirement of total protection and no major development, and emphasizes the protection and inheritance of the cultural heritage of the Grand Canal. Among them, digital technology is widely used in the plan. The plan proposes to realize the protection and restoration of the cultural heritage of the Grand Canal through digital technology, including the application of laser scanning and 3D modelling. Digital means can also be used for the digital transmission and popularization of the cultural heritage of the Grand Canal, such as virtual reality technology and digital exhibitions. At the same time, digital technology is also used in the management of the protected area and the development plan of the Grand Canal Cultural Heritage Ecological Protection Zone aims to implement the overall requirement of "total protection, no major development". The plan emphasizes the protection of the Grand Canal as the basic principle throughout the protection and inheritance work, covering the management and care of the river and waterway system, ecological environmental protection and restoration, integrated development of cultural tourism and urban and rural infrastructure construction. Among them, the application of digital technology plays an important role.

In addition, the construction of the Grand Canal Cultural Heritage Ecological Protection Zone has also introduced special regulations. 2021-2022, Gongshu District Government compiled a master plan for the creation of the protection zone, formulated sub-planning and creation of the implementation programme, and issued the "Implementation Opinions on the Creation of the Grand Canal Cultural Heritage Ecological Protection Zone", which constructed a planning system for the implementation of the creation of the protection zone.

3 Major projects for the sustainable development of the Grand Canal Cultural Heritage Ecological Protection Zone

3.1 China Grand Canal Museum: Smart Museum.

China Grand Canal Museum is the first large-scale thematic museum in China with the theme of canal culture, and is currently committed to building the museum into a sustainable and intelligent museum through digital and intelligent construction, as well as the effective protection and dissemination of data resources. It is located in the Canal Culture Square in the north of Hangzhou city, near Gongchen Bridge at the southern end of the Grand Canal. The museum was built on 1 October 2006 and was upgraded in 2023. The museum has a floor area of 10,700 square meters and over 5,000 square meters of exhibition space. The China Grand Canal Museum is uniquely designed in a fan shape around the Canal Culture Square. The building adopts a combination of flat slopes and an open layout, integrating indoors and outdoors, utilizing physical display elements such as the ancient canal, bridges, boats and docks. The museum provides an all-round, multi-angle collection of canal culture materials, protection and research, and shows the natural features and history and culture of the Grand Canal. The revamped museum highlights the southern end of the canal and local characteristics, with organized exhibition lines and a focus on visitor experience. The new exhibition system includes a permanent basic exhibition, Bridging North and South: The Opening, Changes and Influence of the Grand Canal, and a permanent special exhibition, Rising from the River: The Story of the Grand Canal and the City of Hangzhou. In addition, there are two special exhibitions, "Canal Comprehensive Protection Hangzhou Model" and "Millennium Canal: The Source and Flow of the Canal", as well as a digital experience area, "Grand Canal Digital Cockpit". Wang Ziwei pointed out that the construction of the Intelligent Museum of Non-Heritage can reach a two-way communication between people and non-heritage, and provide a digital display platform for the display of non-heritage, and the construction of the Intelligent Museum of Non-Heritage has become a new trend in the digital protection of non-heritage.[3] China Grand Canal Museum has strengthened the digital construction in the latest renovation, as shown in Fig. 1. The museum now integrates various functions such as showing the characteristics of the canal, collecting canal relics, researching canal culture, and demonstrating the comprehensive protection of the canal, which is regarded as filling the gaps of the

museum in China, and becoming one of the important canter of the history and culture of the canal in the country.

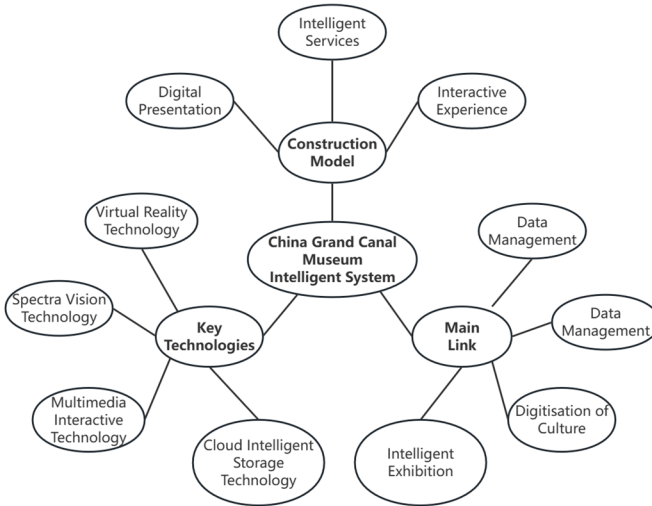


Fig. 1. China Grand Canal Museum Intelligent System

3.2 Grand Canal Hangzhou Iron and Steel Industrial Site Comprehensive Protection Project: Thematic Exhibitions.

The Grand Canal Hangang Industrial Site Comprehensive Protection Project aims to be an important project integrating the sightseeing of the old industrial site, the agglomeration of digital technology industries, and the integration of cultural creativity. It is located in the west of Hangzhou Mid-levels National Forest Park and the east of the core area of Great City North, with a planning area of about 560,000 square meters, and is scheduled to be completed and opened in 2023 as a whole. The core landscape of the project is Hanggang Lake, which provides a rich and diverse range of water activities by opening up the water system in the north and south of the site to form a water function cluster in the Greater City North Demonstration Area. Meanwhile, the project also includes a number of indoor and outdoor freely linked activity spaces, such as Hanggang Calligraphy, Painting and Literature Museum, Hanggang Folk Culture Museum, Industrial Culture Museum, Digital and Intelligent Life Museum, water buses and sightseeing tour boat distribution center, to satisfy the public's needs for green leisure and cultural experience. It makes full use of the industrial site of Hangzhou Iron & Steel on the Grand Canal, and is committed to creating a model for the transformation of high-class industrial sites, an international center for arts and culture and sports, and a gathering place for fashionable leisure and humanistic life. The project aims to demonstrate the historical value of the industrial site and the vitality of the contemporary city through innovative design concepts and an integrated development model. The construction of the Grand Canal Hangzhou Steel Industrial Site Comprehensive

Conservation Project will fully preserve and display the historical elements and cultural memories of the industrial site, and attract people to visit and experience the site through creative design and rich activity contents. On this basis, the project will also focus on the development of artistic creativity and diversified cultural activities to create an international center for arts and sports. The atmosphere is created based on the commemorative theme and aesthetic rules, and how to create the atmosphere is particularly important for the design of commemorative exhibitions.⁴ The project will organize cultural exhibitions, art performances and bazaars to attract more people to come here to experience the collision and integration of the industrial base and the modern city, and to make it a benchmark for urban development in Hangzhou and the Yangtze River Delta region. The Grand Canal Hangzhou Steel Industrial Site Comprehensive Conservation Project provides new ideas and models for the diversity and sustainable development of urban culture.

3.3 Grand Canal Future Art and Technology Center: Multi-Purpose Venues.

Cultural venues are characterized by complex spaces and systems, and high requirements for reliability and comfort in operation and maintenance.⁵ The Grand Canal Future Art and Technology Center project will create a multi-functional cultural center that will integrate art, technology, creativity and cultural activities. It is at the original site of Hangzhou Oil Refinery, located in the former industrial area at the southern end of the Beijing-Hangzhou Grand Canal, and the nature of the land is park green space compatible with plaza green space and land for cultural facilities. The project is located in the core area of Hangzhou Canal New City, adjacent to the Beijing-Hangzhou Grand Canal, the Grand Canal Museum and the Eco-Art Island, and is an important part of the Grand Canal National Cultural Park Demonstration Zone. The project is divided into four main functional areas: First, the Art and Technology center: the center will provide exhibition space, master studios, interdisciplinary experimental displays and other functions, aiming to promote the cross-fertilisation of art and technology, and to showcase innovative and cutting-edge art forms and technological applications. Secondly, the International Creative Industry Park: the park will introduce knowledge-intensive industries centered on Technological innovation and cultural creativity, to create an internationally competitive creative industry park, and to promote cross-border integration and innovative development of industries. Thirdly, the Art and Culture Creative Block: this block will become a commercial support for the Cultural center, and on the basis of preserving industrial heritage, it will create a commercial model for the integration of art, culture and technology, and provide a commercial space that serves the needs of industrial development and consumption. Fourthly, the Oil Refinery Park: as a venue for the display of artistic and cultural vitality, the park will host various art seasons and festivals, bringing together the artistic and cultural atmosphere and becoming a unique place for people to experience art and culture. Taking the Hangzhou Oil Refinery as a starting point, the design team takes the industrial heritage as inspiration and integrates the preserved industrial relics into the design, transforming the site from a private space to a public space, from a factory to a cultural center, and from petroleum to a renewable energy source, injecting new vitality and cultural connotations into the

development of the Hangzhou Canal New Town, and attracting more people to come and experience the charm of the fusion of art and science and technology.

4 Technological innovation for sustainable development of the Grand Canal Cultural Heritage Ecological Protection Zone

The construction of the Grand Canal Cultural Heritage Ecological Protection Zone adopts a large number of digital technologies, as shown in Fig. 2. Gongshu District of Hangzhou has actively made use of the opportunity of building Hangzhou's "First City of Digital Governance" to break down digital barriers, and has joined hands with various departments to make full use of digital technology to enhance the digital protection level of the Grand Canal heritage in all aspects, including resource management, monitoring and early warning, ecological protection, construction-related project management, planning implementation, and public services.

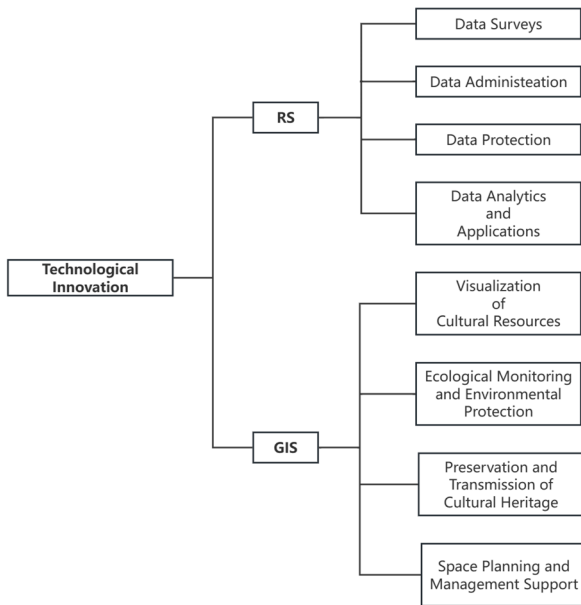


Fig. 2. Grand Canal Cultural Heritage Ecological Reserve

4.1 Technological Innovation of Remote Sensing Technology in the Resource Survey of the Grand Canal Cultural Heritage Ecological Protection Zone

Under the guidance of the Zhejiang Provincial Cultural Relics Bureau, Gongshu District of Hangzhou City has jointly constructed a Grand Canal ecological monitoring system with a number of units, which realizes a single interface overview of the basic

data of the Grand Canal (Zhejiang section), and horizontal synergy of data from multiple sectors such as natural resources, ecological environment, transportation and water conservancy, which helps to enhance the protection and management capacity of the Grand Canal. In cultural and ecological protection zones, remote sensing technology is mainly used to acquire and analyze spatial information on the surface of the ground to support the planning, management and monitoring of the protection zones. The Grand Canal Cultural Heritage Ecological Protection Zone launched the Gongchen Bridge 3D digitization project in 2018, using a combination of multiple technical routes such as multi-image 3D reconstruction, 3D laser scanning, high-precision texture automatic mapping, and drone tilt photography to retain 3D information on the surface of the Gongchen Bridge, to measure and record the environmental information of the construction control zone of the Gongchen Bridge and to carry out all-round 3D digitization. The clever combination of this digitization and remote sensing technology makes the Grand Canal Cultural Heritage Ecological Reserve achieve innovative results in the process of resource investigation.

Technological innovation in data survey - multi-temporal remote sensing monitoring.

Resource survey is one of the basic tasks in the construction of cultural and ecological protected areas, while remote sensing technology provides the ability to comprehensively understand the distribution of the natural environment and cultural resources in the protected areas by obtaining large-scale and high-resolution image data. Through remote sensing technology, it is possible to classify and monitor land use types, assess vegetation cover, and monitor waters and wetlands, providing accurate data support for resource surveys. In the Grand Canal Cultural Heritage Ecological Protection Zone, multi-temporal remote sensing monitoring is applied, using multi-source remote sensing data, including high-resolution satellite imagery, aerial imagery and drone data, to form multi-temporal observational datasets in order to track and analyse the environmental dynamics of the Grand Canal area, and to provide support for accurate resource investigation and protection.

Technological Innovation in Data Management - Feature Classification and Change Detection.

Monitoring and management is an important part of the construction of cultural and ecological protected areas. Remote sensing technology can provide data with high spatial and temporal resolution, which provides important support for the monitoring and management of cultural and ecological reserves. Through remote sensing technology, real-time monitoring and analysis of environmental elements such as vegetation cover, land use change, water resource status, etc. in the cultural ecological reserve can be achieved. Feature classification and change detection can be applied in the Grand Canal Cultural Heritage Ecological Protection Zone, using remote sensing image classification and change detection techniques to transform remote sensing data into map information and to monitor changes in land use, vegetation cover and building expansion. By comparing image data from different time periods, it assesses the impact of human

activities on protected areas and the evolution of the natural environment. It helps managers to discover and warn of environmental changes in time, formulate reasonable ecological restoration and protection measures, and promote the improvement and adjustment of the ecological environment.

Technological Innovation in Data Protection - Heritage Detection and Assessment.

Cultural heritage protection is an important part of the construction of cultural and ecological protection zones. The innovation in the application of remote sensing technology in cultural heritage protection can provide important data support to help realize the protection, restoration and inheritance of cultural heritage. In the Grand Canal Cultural Heritage Protection Zone, high-resolution remote sensing image data can be acquired to achieve fine monitoring and assessment of the cultural heritage of the Grand Canal. Remote sensing technology provides three-dimensional models of cultural heritage buildings, texture information, etc., which helps protectors to monitor and assess the damage of cultural relics and take timely protection measures.

Technological innovation in data analysis and application - spatial analysis and decision-making support.

The innovative application of remote sensing technology in the planning and decision-making of cultural and ecological protected areas can provide comprehensive spatial information and decision-making support.⁶ Data obtained through remote sensing technology can help planners gain a comprehensive understanding of the distribution of natural and human elements in protected areas, including land use, vegetation types, water resources, transportation networks, etc., so as to more accurately carry out regional planning and decision-making. In the Grand Canal Cultural Heritage Ecological Protection Zone, remote sensing data can be used in conjunction with geographic information systems (GIS) for spatial analysis and modeling to extract key ecological indicators of the Grand Canal area. These indicators help planners and managers to quantitatively assess the value of cultural resources and environmental vulnerability, providing a scientific basis for decision-making.

4.2 Technological Innovation of Geographic Information System in the Construction of Cultural and Ecological Reserves

Geographic Information System (GIS) is a technical system that integrates spatial data collection, storage, management, analysis and presentation. By combining geospatial data with attribute data, it can carry out comprehensive analysis and visual presentation of geographic phenomena, and provide scientific basis for the planning, management and scientific decision-making of the protected area by providing multi-angle and all-round geographic information support. With the help of China Grand Canal (Hangzhou Section) World Cultural Heritage Monitoring General Platform, Gongshu District of Hangzhou City has for the first time used GIS, network and other high-tech to realize "spatial and temporal monitoring, dynamic early warning" of the giant and living heritage, and manage monitoring and early-warning information of the entire Grand Canal,

which lays an important foundation and provides powerful support for the sustainable development of the Grand Canal Cultural Heritage Ecological Protection Zone. It has laid an important foundation for the sustainable development of the Grand Canal Cultural Heritage Ecological Reserve, provided powerful support, and provided an important model for the construction of the monitoring and early warning system of China's world cultural heritage.

Technological Innovation in Visualizing Cultural Resources - Geospatial Database Construction.

GIS provides strong support for the survey and assessment of cultural resources in cultural ecological reserves by collecting and integrating various geospatial data, such as remote sensing images, digital maps and geographic information. Aerial photography and satellite remote sensing technology are used to obtain information on surface cover, vegetation and land use in the protected area. Combined with the data processing and integration functions of GIS, a detailed distribution map of cultural resources is generated, which further assists the assessment and protection of cultural resources. Secondly, GIS can quantitatively analyze and model cultural resources through various geographic information analysis methods, such as spatial interpolation, spatial correlation and spatial statistics, so as to better understand the distribution and evolution trend of cultural resources in the protected area. Through the analysis function of GIS, the analysis of geospatial distribution of cultural elements such as cultural landscapes, historical sites, traditional villages and so on can be realized, further revealing the characteristics and laws of cultural resources, and providing scientific basis for the planning and management of cultural ecological protection areas.

Technological Innovation in Ecological Monitoring and Environmental Protection - Data Collection and Integration.

GIS provides a comprehensive understanding of the ecological environment status of cultural ecological reserves by integrating multi-source data, such as remote sensing images, geospatial data and sensor data. High-resolution image data acquired by remote sensing technology are used to monitor the vegetation cover, land use, and wetland distribution of the protected area. Combined with the spatial analysis function of GIS, it can carry out monitoring and assessment of ecological environment changes in different time scales, providing scientific basis for ecological protection and environmental management. Secondly, GIS can divide and evaluate the ecological functional areas based on the spatial analysis method. Combining the ecological environment data and biodiversity data in the cultural ecological reserve, it can quantitatively assess the value and vulnerability of biodiversity and provide scientific basis for biodiversity protection in the cultural ecological reserve. And through the ecological function analysis of the GIS, it helps the planners and managers to clarify the ecological function positioning of different areas in the protected area, which further promotes the protection and restoration of biodiversity.

Technological Innovation in Cultural Heritage Protection and Inheritance - Digital Management System.

GIS achieves digital protection and reconstruction of cultural heritage by collecting information such as remote sensing images and 3D scanning data of cultural heritage, and combining 3D modeling and visualization technology of GIS.⁷ GIS can quickly generate high-precision digital models for the detailed recording and protection of cultural heritage. Through the digital protection of GIS, the visibility and protection effect of cultural heritage is improved so that it can be better inherited and utilized. Secondly, GIS combines cultural heritage with other information resources for spatial analysis and planning, so as to realize the sustainable use and development of cultural heritage. By analyzing the spatial distribution, accessibility, environmental characteristics and other factors in cultural heritage and protected areas, the potential and suitability of cultural heritage for development can be determined. GIS can also simulate the impact of different development methods on cultural heritage, and provide scientific decision-making basis for the sustainable use of cultural heritage with the help of decision-making support function of GIS.

Technological innovation in spatial planning and management support - spatial decision-making and assessment.

GIS can carry out regional planning and land use analysis by integrating geospatial data and geographic information. Through the spatial analysis function of GIS, the impacts and conflicts of different land use types in protected areas are assessed to provide scientific decision support for planning and managers. The land use analysis of GIS guides the rational use of land resources, the coordinated development of economic development and ecological protection in the protected areas. Secondly, GIS, as an important part of spatial decision support system, can provide a variety of data and technical means to assist decision makers in spatial planning and management. By integrating different data sources and models, GIS can simulate and compare the effects of different decision-making scenarios and help decision-makers make optimal decisions. The spatial decision support function of GIS can reduce uncertainty and provide more scientific and comprehensive decision support for planning and management.

5 Conclusion

The value of the sustainable development of the Grand Canal Cultural Heritage Ecological Reserve lies in realizing the mutual integration of cultural heritage protection and ecological protection, forming a sustainable development path that takes into account safeguarding the stability of the ecological environment and the protection of biodiversity, enhancing the value of the cultural heritage and the social benefits, and promoting the development of economy and culture in the region. After analyzing the relevant policies, major projects and construction status of the Grand Canal Cultural Heritage Ecological Reserve, it can be seen that the Grand Canal Cultural Heritage Ecological Reserve has already formed a multi-dimensional policy framework concerning the cultivation of non-heritage talents and the excavation of craft resources, and has

achieved initial construction results. Among them, digital reform has become an important means of cultural heritage protection and inheritance.

In conclusion, this thesis puts forward suggestions for the sustainable development of the Grand Canal Cultural Heritage Ecological Reserve in terms of technological innovation, helps cultural and ecological protection to integrate with each other, promotes the development of economy and culture in the region, improves the benign cultural development of the whole society and the protection of the ecological environment, and provides valuable references for the protection and development of similar regions or similar fields.

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