



Research on the Development Strategy of Urban Cultural Landscape in Guangdong-Hong Kong-Macao Greater Bay Area based on GIS

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Abstract. According to the correlation between GIS and urban cultural landscape, taking the urban cultural landscape of Guangdong-Hong Kong-Macao Greater Bay Area as the research object, this paper analyzes the urban cultural landscape by using GIS and combining the research methods of design, architecture, urban planning and computer. GIS is applied to the protection of urban cultural landscape to visually present the distribution state and complex spatial relationship of urban cultural landscape, so as to facilitate the management and application of digital information; To analyze all kinds of information through GIS, ensure the complete presentation of urban cultural landscape to the maximum extent, reveal the distribution characteristics and dynamic mechanism of the core-edge urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area, and realize the sustainable development model of urban cultural landscape in continuous circulation.

Keywords: The Guangdong-Hong Kong-Macao Greater Bay Area, Urban cultural landscapes, GIS, Sustainable development.

1 Introduction

GIS is geographic information system, including spatial data collection, integration, analysis, storage, display, dissemination, etc., to solve the problem of time and space, widely used in architecture, landscape architecture, design and other disciplines. GIS has the significant advantages of spatial, dynamic, efficient integration of information technology and processing ability in spatial information analysis and data processing, which directly reflects the spatiotemporal changes of regional cultural landscape and provides theoretical guidance and analytical means for the study of cultural landscape.

Urban cultural landscape is the main component of urban form and style characteristics. According to the characteristics of urban cultural landscape in Guangdong-Hong Kong-Macao Greater Bay Area, it can be divided into seven types, namely, folk cultural landscape, modern urban cultural landscape, urban ecological cultural landscape, urban

celebrity cultural landscape, urban red cultural landscape, urban religious cultural landscape, and urban night tour cultural landscape. The combination of GIS and the study of the cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area expands the connotation of GIS and speeds up the research process of the cultural landscape. It is an effective starting point for implementing the development strategy of the Greater Bay Area, focusing on the sustainable development of urban agglomerations, strengthening environmental protection, enhancing the competitiveness of the Greater Bay Area, and creating a quality living environment suitable for living, business and tourism. With the establishment and management of GIS resource information database, the spatial quantification of the cultural landscape of Guangdong-Hong Kong-Macao Greater Bay Area is realized; To realize spatial analysis of cultural landscape data of Guangdong-Hong Kong-Macao Greater Bay Area by means of data overlay analysis, spatial analysis and other functions; With the help of GIS and its interdisciplinary derivation, it provides technical support for digital information collection, digital restoration and visual representation, digital display and dissemination for the protection of urban cultural landscape, and also provides a platform and space for the development of urban cultural landscape, so as to promote the sustainable development of urban cultural landscape.

2 Research Summary and Value Significance

Since the birth of GIS in the 1960s, due to the rapid development of science and technology and statistics in the 1990s, many scholars in Europe and the United States have used GIS to carry out research on cultural landscape. For example, Bishop D, a scholar, tried to use GIS to build an ecological assessment model of cultural landscape in 1994 [1]. In the 21st century, the popularization of computer technology and the innovation of new theories enhanced people's ability to investigate cultural landscape resources and extract elements, which led to the quantitative and comprehensive development of research directions. In 2015, Del Castillo et al. used the integration of GIS and remote sensing technology to realize the visual expression of the forest cover change process in Moncayo Natural Park [2]. In 2016, Nekhay O et al. used AHP and GIS related technologies to evaluate the agricultural cultural landscape [3]. In 2022, Mizuuchi and Yusuke used GIS to explore the hot spot distribution and landscape evaluation of Daoali Mountain Walking Trail, revealing the impact of landscape characteristics and spatial changes on hot spot areas [4].

The research on GIS in China began in the 1970s and 1980s, but the cross-over research in the early stage was shallow and the theoretical basis was not profound. In 1976, Professor Chen Shupeng initiated the concept of "GIS" [5]. In 1980, China's first GIS laboratory was established, which laid a cornerstone for subsequent research and application. Since 1986, GIS has been gradually applied to multidisciplinary fields and ushered in a preliminary period of development. In 1987, the launch of PURSIS (Remote Sensing Information System of Peking University) was regarded as a milestone in the development of GIS software in China [6]. In the 1990s, domestic scholars made

active use of GIS, opening a new chapter in the study of cultural landscape. Liu Huiming used GIS to evaluate the visual sensitivity of cultural landscape. In 2003, Academician Chen Shupeng pointed out that spatial information technology can study the spatial-temporal evolution of civilization from the perspective of space [7]. In 2007, Wang Bin and Sto Shangji, in *Analysis of Guangdong Geographical Name Cultural Landscape Based on GIS*, used GIS to study the geographical and historical characteristics of Lingnan in Guangdong Geographical name cultural landscape [8]. In 2008, Li Fan in the *Application and Prospect of GIS in the Study of History and Cultural Geography* proposed that the application of GIS in the study of history and culture should be included in the digital city plan [9]. In 2017, Zhang Wenjuan and Lin Xufang proposed the positive correlation between geographical name density and population density distribution in *GIS-based Analysis of Geographical Name Cultural Landscape in Zengcheng District, Guangzhou* [10]. On CNKI, there are 5955 articles searched by the keywords "GIS" and "landscape", 227 articles searched by the keywords "GIS" and "cultural landscape", and only 1 article searched by the keywords "GIS", "cultural landscape" and "Guangdong-Hong Kong-Macao Greater Bay Area". It can be seen that, the research on urban cultural landscape of Guangdong-Hong Kong-Macao Greater Bay Area based on GIS is very limited, and there are few papers on the use of "GIS for urban cultural landscape."

As a whole, the above researches focus on GIS and geographical name cultural landscape, and the application of interdisciplinary fields, etc. There are few researches on the application of GIS in urban cultural landscape. With the development and rise of information technology and digital technology, in the urban cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area, there is still a lack of two-dimensional and three-dimensional models to organize the urban cultural landscape, and it is unable to provide accurate data and visual presentation. GIS has gradually become an important technical support in the protection and development of urban cultural landscape. Using GIS to conduct quantitative research on the urban cultural landscape of the Greater Bay Area, sustainable development of urban cultural landscape resources and resource sharing.

In developed countries, urban cultural landscape has shown a rational and diversified development trend [11]. With the help of scientific and technological means, attention is also paid to the digital protection and sustainable development of cultural landscape with the intervention of GIS. The purpose of the study on urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area is to analyze the current development status of urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area, organize and summarize the digital protection and sustainable development of cultural landscape, respond to the "Belt and Road" initiative, and take urban cultural landscape as the carrier. To explore the research content and theoretical framework for realizing the digital protection and sustainable development of the urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area, build a database based on GIS database management and analysis of the urban cultural landscape, improve the quality of life in the Guangdong-Hong Kong-Macao Greater Bay Area, and inherit the regional culture. (Fig. 1)

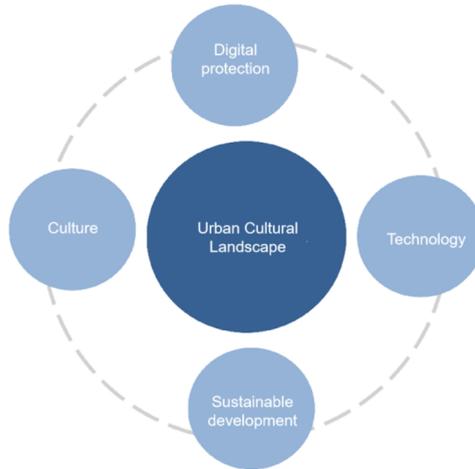


Fig. 1. Digital framework for urban cultural landscape in the Greater Bay Area.

The rich cultural deposits of the Guangdong-Hong Kong-Macao Greater Bay Area are reflected in the construction of urban cultural landscapes and folk customs, and the historic cultural landscapes currently preserved and restored have played an immeasurable role in the development of the region. With a history of thousands of years, the Greater Bay Area has formed an urban cultural landscape with rich culture. It is characterized by conforming to nature, respecting folk customs, emphasizing practical results and being good at absorbing, and embodies the regional cultural characteristics of harmony between nature and man, openness and compatibility, and innovation [12]. Based on geographical location, this paper takes more than 420 cultural landscapes of various types in the Greater Bay Area as research objects, and organizes personnel to carry out research activities. Through this field survey, we will gain an in-depth understanding of the current situation and problems of the cultural landscape construction in the Guangdong-Hong Kong-Macao Greater Bay Area, combine the experience of cultural landscape construction in international and domestic cities, and put forward targeted suggestions suitable for the digital protection and sustainable development of the urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area. To make use of GIS to study the urban cultural landscape of Guangdong-Hong Kong-Macao Greater Bay Area, integrate cultural landscape resources and realize resource sharing and dissemination, and promote digital cultural landscape construction; To establish a database of urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area through GIS, establish a spatial information collection and classification system of cultural landscape, establish technical standards for data collection of urban cultural landscape, and explore the driving force for digital protection and sustainable development of urban cultural landscape.

3 Research Status

The Greater Bay Area is hot in summer and warm in winter. It consists of nine cities including Hong Kong, Macao, Guangzhou and Shenzhen (Figs. 2 and 3). Its cultural category belongs to Lingnan culture and its urban cultural landscape resources are abundant. Through the investigation of the Guangdong-Hong Kong-Macao Greater Bay Area, the overall distribution of its cultural landscapes shows a radiate pattern of Guangzhou-Shenzhen-HongKong-Macao, Dongzhou-Foshan, Zhuhai-Hui-Zhongzhaojiang region. The representative cultural landscapes are mostly concentrated in the Pearl River Delta region, which has more advantages than other regions in terms of quantity and quality, and the protection and development situation has a positive relationship with the economic level.

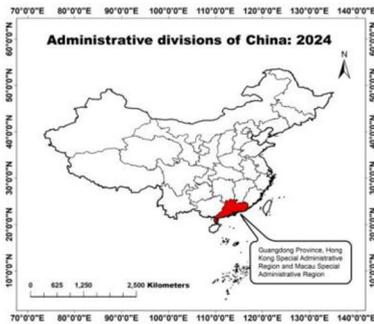


Fig. 2. Location map of Guangdong.



Fig. 3. Guangdong-Hong Kong-Macao Greater Bay Area.

The profound cultural heritage of Guangdong-Hong Kong-Macao Greater Bay Area and the importance attached by successive governments to the construction of cultural landscape make the construction of urban cultural landscape in the Greater Bay Area in the forefront of China. However, since the reform and opening up, the Greater Bay Area has experienced the process of urbanization and information technology, and the contradiction between urban construction and multiculturalism has become increasingly prominent, and the ecosystem is facing enormous pressure. There are many problems in the protection and inheritance of urban cultural landscape, such as lack of spatial information collection technology, imperfect tracking and monitoring management, lack of regional culture, lack of theme identification, lack of awareness of green environmental protection and sustainable development, inability to integrate surrounding resources, long-term systematic improvement, lack of established value evaluation system, lack of institutional protection and other problems.

4 Results

Taking the urban cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area as the research object and starting from the digital protection of the urban cultural

landscape based on GIS, the sustainable development of the urban cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area is achieved through the following aspects through the use of digital methods such as visual and image collection and sorting of resources related to the cultural landscape based on systematic data.

4.1 Collection of Spatial Information Based on Digital Classification System (Theoretical Discussion)

The three basic components of GIS are geographical basis, standardization and digitalization, and multi-dimensional structure [13]. The spatial basic data of GIS, originated from Chinese basic topographic maps, are widely recognized as the digital data set that encapsulate geographical features of these maps. Essentially, GIS stands as the inheritance and development of map surveying and mapping databases. The advancements in space technology and the innovations within information society science and technology have endowed GIS with a more comprehensive and enriched spatial information connotation, marking a substantial departure from the traditional concept of "map surveying and mapping support system". GIS can integrate diverse data, enhance the precision of urban geospatial data collection, organization, classification, and analysis. This, in turn, assists urban cultural landscape management departments and design institutions in swiftly acquiring accurate cultural landscape data, thereby providing crucial support for effective decision-making in urban cultural landscape planning (Fig. 4). Related information systems also include database management system (DBMS), decision support system (DSS) and expert system [14]. Currently, GIS technology, geographic information science, and geographic information services are converging towards a trend of integrated and comprehensive development [15]. Research areas such as spatial data mining and knowledge discovery have emerged as the forefront of academic exploration [16], while the construction of smart cities and the promotion of ecological civilization have become new, promising applications that showcase the expansion and growth of these fields. Through a systematic survey of the cultural landscape in Guangdong, Hong Kong and Macao, the current situation of the urban cultural landscape in the Greater Bay Area is deeply understood, and the original fragmented cultural landscape points are integrated through the concept of urban cultural landscape groups. Relying on the digital classification system, the database of the huge and complex cultural landscape resources formed by the integration will be established to provide a basis for three-dimensional urban cultural landscape.

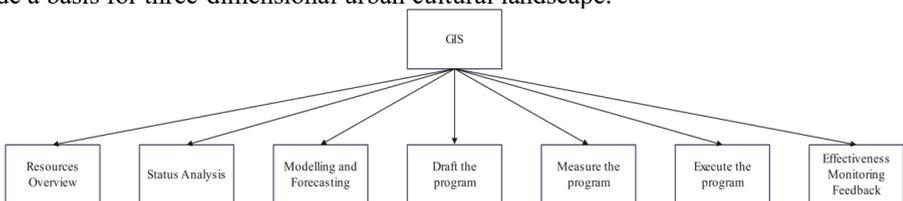


Fig. 4. GIS working flowchart.

4.2 Based on GIS and Other Information Research Methods, Establish a Database (Practical Steps)

GIS serves dual purposes as both a database storage system and an urban planning tool. At the database level, GIS facilitates the storage and linkage of spatial and textual data through a geo-relational model. As a planning tool, GIS offers geoprocessing capabilities, including map overlay, connectivity measurement, buffer analysis, and more. It possesses the ability to extract core elements from multi-dimensional evaluation indicators, assign weights to them, and conduct comprehensive assessments, ultimately yielding comprehensive evaluation results. With the power of GIS, the key components of spatial data in GIS, such as location information, attribute information and spatial relationship information, can be accurately represented by geocoding, and the relevant data can be further refined into various geographical elements and phenomena by using the geographic information classification mechanism [17]. The combination of GIS visualization technology and computer visualization technology can realize the visual presentation of multi-source, massive and dynamic data. GIS software constitutes a vital component and core foundational software within the modern geographic information industry. Currently, there are more than 20 kinds of GIS basic software in the world, with ArcGIS software holding a dominant position in the international market. Through theoretical research and empirical study, ArcGIS software is used to screen, sort, process and superimpose historical data and trend data contained in geographic information (Table 1). From the spatiotemporal bidirectional dimension and macro to micro multi-level cultural landscape research, GIS combines maps, photos, documents, etc., to build the urban cultural landscape database of Guangdong, Hong Kong and Macao. In order to promote the development direction of urban cultural landscape, seek effective ways for modern technology to intervene in cultural landscape, and promote the development of urban cultural landscape design theory and practice.

Table 1. Data analysis map of ArcGIS software.

| Step | Features | Content |
|------|-------------------------------|---|
| 1 | Data import | Location information, attribute information, spatial relationship information |
| 2 | Data processing | Data attribute extraction, integration and formatting |
| 3 | Data quality inspection | Input check, topology check, data check |
| 4 | Coordinate transformation | To the national 2000 coordinate system |
| 5 | Data integration, warehousing | Use geographic relational model to store and associate spatial and text data |

4.3 GIS Data Analysis and Rule Summary of Urban Cultural Landscape in Guangdong-Hong Kong-Macao Greater Bay Area

With the help of GIS, it is convenient to process and analyze seven types of spatial data of urban cultural landscape. The seven layers together constitute the basic framework

of urban cultural landscape, identify and evaluate the value of urban cultural landscape, including the key indicators such as conservation status, ontology value and urban integration degree. Then, GIS is used to carry out core density comparison analysis of information, and quantify the value of historical cultural landscape. To provide a scientific basis for urban design and cultural protection. In addition, GIS can also facilitate the analysis of the spatial and temporal evolution pattern of urban cultural landscape, and study the evolution of the cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area through models such as gravity transfer model and expansion evolution, reveal the evolutionary characteristics of the urban cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area, and provide countermeasures for the evolution of the urban cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area.

4.4 The Integration, Synthesis and Reorganization of GIS and the Concept of Sustainable Development Can Realize the Harmonious Development of the Urban Cultural Landscape in the Greater Bay Area

Over the past decade, the realm of GIS applications has expanded considerably, particularly in crucial domains such as socio-economics, health, sustainable development, and urban environmental construction. In the context of smart city construction projects, the integration of BIM and GIS technologies has led to numerous practical applications, encompassing topographic surveying, design optimization, site planning, virtual scene creation, collaborative progress management, safety and environmental monitoring, as well as personnel location and management. GIS is used to systematically lay out the elements of urban cultural landscape, connect contiguous development and construction, balance the fragmented cultural landscape scattered in the city, and build a complete urban cultural landscape system. The traffic relationship is sorted out, The Times and culture are taken into account, and the quality of urban cultural landscape space is reflected by human activities. For example, the construction of Lingnan Xintiandi greatly improved the overall quality of urban cultural landscape; The southern wind ancient stove in Foshan, through the overall renovation, the introduction of artist groups and various commercial forms, improved the diversity of space and people. In combination with green technology, digital protection and sustainable development of urban cultural landscape are promoted. For example, water treatment technology is used to maintain the self-circulation of site water, irrigation of garden plants and water features, and solar and wind energy are utilized to provide clean energy for cultural landscape space. Form an inexhaustible driving force for urban cultural landscape, absorb western advanced development experience, inject the concept of green, energy saving, low-carbon and environmental protection into urban cultural landscape, promote the integrated development of cultural landscapes and natural landscapes, such as Shenzhen Vanke Headquarters building (Fig. 5), Guangzhou Meteorological Appreciation Early Warning Center (Fig. 6), etc., and carry out cultural landscape design relying on green concepts.



Fig. 5. Headquarters building of Vanke in Shenzhen.



Fig. 6. Guangzhou meteorological appreciation and early warning center.

4.5 GIS Integrates with Multiple Technologies Such as Network and Multimedia to Build a Digital Interactive Platform

With the support of emerging technologies such as "Smart Earth" and "cloud computing", geospatial information services have emerged as the linchpin for integrating and effectively utilizing geospatial information. Considering the national geographic information public service platform, "Map World", as an exemplary case, this comprehensive geographic information service system, grounded in the Internet, offers "one-stop" geographic information services to enterprises and the public through portal and secondary development interfaces. Professional departments, enterprises, and individual users can effortlessly obtain and integrate their extensive geographic information resources into existing GIS application systems and service websites, leveraging the standardized service interfaces and APIs provided by "Map World". Alternatively, they can build an entirely new GIS application platform with these tools. This mechanism dramatically cuts down the cost and time required for GIS application development, bypassing the significant expenses associated with public geographic framework data processing and underlying service maintenance. Consequently, it effectively enhances the efficiency of surveying and mapping public services, and substantially contributes to the prosperity and advancement of the geographic information industry. The rapid development of digital technologies such as GIS, multi-spectral image recognition and machine learning has improved the efficiency and accuracy of the identification of cultural landscape features and elements, and provided important technical methods for the management of urban cultural landscape feature information and data. Multi-technology integration is used to build an urban cultural landscape network interactive platform, which integrates the functions of industry dynamic sharing, 3D visual display of cultural landscape and dissemination of policies and regulations, and creates immersive and trans-time and space urban cultural landscape experience opportunities for the public through mobile phone + network and other modes. Relying on the strong interaction of the Internet, combined with VR technology, the real representation of urban cultural landscape and the multiple interaction between online and offline are realized, which further promotes the transformation of urban cultural landscape feature assessment to

the core method of digital protection, and promotes the intelligent process of cultural heritage protection and urban cultural landscape management.

4.6 Formulate Policies to Provide Institutional Guarantee for the Sustainable Development of Urban Cultural Landscape

In March 2021, the Ministry of Natural Resources and the State Administration of Cultural Heritage issued the Guiding Opinions on Strengthening the Protection and Management of Historical and Cultural Heritage in the Preparation and Implementation of National Land and Space Planning, which clearly stated that a database of historical and cultural heritage resources should be established and incorporated into the basic information platform of national land and space. Through mechanism building, a database will be established on the cultural landscape of historical sites and former residences of celebrities, which will facilitate the daily management and services of the government. At the same time, preferential policies in terms of approval, taxation and management will be given to the development subjects of cultural landscapes that invest in the construction of spatial information technology.

5 Conclusion

The sustainable development of the urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area should not only deal with the relationship between GIS, digitalization and the concept of sustainability, but also pay attention to the diversity and compatibility of regional culture, and pay attention to the local characteristics of the Guangdong-Hong Kong-Macao Greater Bay Area. With the support of GIS, combined with people's needs, absorbing traditional culture and applying sustainable concepts such as green and ecological, the core-periphery distribution characteristics and dynamic mechanism of the urban cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area are revealed, so as to find a new road for the construction of the urban cultural landscape of the Guangdong-Hong Kong-Macao Greater Bay Area. While deepening the heritage of traditional culture, strengthening the application of Lingnan style in the urban cultural landscape. In a globalized economic environment, the urban cultural landscape not only reflects the regional cultural heritage, but also radiates a green atmosphere, forming an ecological, green and sustainable urban cultural landscape space with the characteristics of The Times and regional culture, and comprehensively enhancing the image and comprehensive competitiveness of the urban cultural landscape in the Guangdong-Hong Kong-Macao Greater Bay Area.

Fund Projects

The 2025 Guangdong Province Graduate Education Innovation Program Project Professional Degree Graduate Teaching Case Library Construction Project "Teaching Case

Library of Sustainable Design Practice from the Perspective of Industry-Education Integration" (2025ANLK_038); In 2022, Guangdong Province Undergraduate Teaching Quality and Teaching Reform Project "Research on Optimization of Curriculum System for Environmental Design Professionals in Guangdong-Hong Kong-Macao Greater Bay Area under the Background of Integration of Production and Education"; 2024 Guangdong University of Finance and Economics Graduate Education Comprehensive Reform project, graduate curriculum ideological and political demonstration project "Sustainable Design Practice" course phased research results; 2025 Annual Graduate Education Comprehensive Reform Project of Guangdong University of Finance and Economics, AI + Graduate Quality Course Construction Project: Phased Research Results of "Sustainable Design Practice" ; The Youth Project of Philosophy and Social Sciences Planning Project of Guangdong Province in 2024, "Research on the Protection and Communication Strategy of Chaozhou Historical and Cultural District under the Vision of Digital Technology and Media Convergence" (GD24YYS13)

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