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Ritual Space Adaptation Under Urbanization: Spatial Patterns and Influencing Factors on Xiamen Island, China

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Abstract

Rapid urbanization has reshaped the built environment of traditional ritual spaces, prompting diverse spatial responses to urban transformation. Understanding these responses is essential for integrating culturally embedded spaces into contemporary cities. Taking Xiamen Island, China, as the study area, this study identifies 353 existing ritual spaces and further examines 239 sites with traceable reconstruction histories since 1980. Standard deviational ellipse, kernel density estimation, spatial autocorrelation, and the Optimal Parameters-Based Geographical Detector (OPGD) are integrated to examine their adaptation types, spatial patterns, and associated factors. The results show that: (1) four spatial adaptation types are identified, independent temple type, concentrated resettlement type, vertical integration type, and embedded type, representing different forms of spatial reorganization under urbanization; (2) ritual spaces generally extend along a southwest–northeast axis and exhibit significant spatial clustering, while the four types differ in distribution range, orientation, and clustering characteristics; (3) urban renewal shows strong explanatory power across the four types, while development intensity, population and economic activities, and policy intervention exert differentiated effects. Factor interactions predominantly exhibit bivariate or nonlinear enhancement. Overall, the findings highlight spatial constraints, community demand, and planning intervention as three interrelated dimensions for understanding ritual-space adaptation, providing insights for culturally sensitive urban renewal and built-environment management.

Keywords: ritual spaces; urbanization; typology; spatial differentiation; optimal parameters-based geographical detector

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1. Introduction

Ritual spaces are physical settings where collective ritual practices intersect with social life. Durkheim distinguished the sacred from the profane and defined rites as rules governing conduct toward sacred things [1]. Smith further highlighted the importance of place, particularly constructed ritual environments, in understanding ritual practices [2]. Subsequent scholarship in the geography of religion has expanded the understanding of the spatial dimensions of religion. Knott examined the relationships between religion and social, cultural, and physical spaces [3], while Kong further developed geographical perspectives on religious practices and places [4]. Although ritual space, sacred space, and religious space are closely interconnected, they emphasize different dimensions: religious space concerns religious practices and their spatial relationships, sacred space highlights the sacred meanings attributed to places, and ritual space foregrounds the settings in which

ritual practices take place. In Chinese cities, ritual spaces function not only as physical settings for worship but also as spatial carriers of community interaction, collective memory, and local cultural practices. In southern Fujian, traditional palaces, temples, and clan ancestral halls, despite differences in their objects of worship and forms of organization, all serve as important architectural settings for collective ritual practices. Accordingly, this study focuses on these extant built sites on Xiamen Island, identifying different spatial adaptation types under urbanization to examine the diverse forms of physical persistence of ritual institutions, their intra-urban spatial differentiation, and the factors associated with these spatial differences.

Rapid urbanization has profoundly altered the physical and social contexts in which ritual spaces are embedded. Land redevelopment, population restructuring, and urban renewal can disrupt established relationships between ritual practices, local communities, and their spatial settings. Yet such processes do not necessarily result in the disappearance of ritual spaces. Evidence from rapidly urbanizing Chinese cities shows that ritual practices and their spatial settings may persist through relocation, spatial reorganization, functional adjustment, and changing relationships with surrounding urban environments [5–7]. These transformations are shaped not only by constraints on physical space but also by shifts in community life, cultural governance, heritage policies, and local development practices. Accordingly, the relationship between urbanization and ritual spaces can be understood not simply as a binary process of preservation or disappearance, but as one of spatial adaptation, whereby ritual spaces are reorganized in response to changing spatial, social, and institutional conditions. Since the establishment of the Xiamen Special Economic Zone in 1980, Xiamen Island, with its longstanding folk-belief traditions, has experienced rapid urban expansion and successive phases of urban redevelopment and renewal. The continued presence of traditional ritual sites amid ongoing changes in the urban built environment, together with available historical records of site reconstruction and relocation, provides a suitable empirical basis for examining their diverse spatial adaptations.

Architectural and urban studies have further examined changes in the physical form and spatial organization of religious and ritual spaces under urbanization. Existing research indicates that shifts in social functions may be accompanied by changes in the internal layout and organization of sacred spaces [8]. More recently, research on urban ancestral temples has integrated building and block-level perspectives to examine changes in internal spatial organization and in the relationship between temples and the surrounding urban fabric [9], while research on religious spaces in Lhasa's historic urban area has examined their spatial compositions and typologies in the context of modernization and urbanization [10]. Together, these studies have contributed to understanding the spatial typology, functional transformation, and spatial organization of religious and ritual spaces in urban contexts.

Advances in GIS and spatial statistics have enabled cultural heritage to be examined across broader spatial scales. Methods such as kernel density estimation (KDE), spatial autocorrelation, and spatial clustering are widely used to characterize spatial patterns and differentiation [11–13]; however, descriptive spatial analyses alone provide limited insight into the contributions and interactions of multiple associated factors. Studies of religious places have also combined spatial distribution analysis with investigations of associated factors, using geographically weighted regression for Christian activity places in Yiwu [14] and XGBoost–SHAP and spatial econometric models for religious sites in the Yangtze River Delta [15]. Geodetector offers a complementary approach by quantifying spatial stratified heterogeneity and assessing the explanatory power and interactions of potential factors [16], and has been increasingly applied to human-geographical phenomena such as traditional villages and cultural heritage [17–19]. Geodetector analysis of Lhasa's Barkhor Historic

Area identified changes in the relative explanatory power of socioeconomic, spatial, and cultural heritage factors across historical periods, with pairwise factor interactions consistently showing greater explanatory power than individual factors [20]. However, the discretization of continuous explanatory variables is an important methodological consideration in Geodetector analysis, as different discretization schemes may affect the resulting explanatory power. To address this issue, the Optimal Parameters-based Geographical Detector (OPGD) further optimizes the discretization of continuous explanatory variables and associated parameters [21–24]. Together, these methods enable the analysis to extend from identifying spatial patterns to examining their associated factors, providing a methodological basis for comparing the spatial differentiation of ritual spaces and its associations with multidimensional urban conditions.

Despite these advances, the relationship between the built configurations of ritual sites and their intra-urban spatial differentiation warrants further examination. Existing architectural and urban studies have provided detailed insights into the morphological, functional, and spatial transformations of religious and ritual spaces, while quantitative spatial studies have examined the distribution of religious sites and their associated factors. Integrating these two perspectives through a documented inventory and a classification based on reconstruction histories and present built configurations allows different forms of spatial adaptation to be compared at the intra-urban scale. Such an approach can further examine how different forms of ritual-space transformation are distributed within a city, and how their present spatial patterns are associated with built-environment, demographic, socioeconomic, and planning conditions. Distinguishing these types also provides a basis for considering the different spatial conditions and conservation needs of ritual sites during urban renewal.

To examine these relationships, this study takes Xiamen Island, China, as an empirical case and develops an analytical framework integrating adaptation-pattern identification, spatial-pattern analysis, and associated-factor detection. A total of 353 existing ritual spaces were identified, of which 239 sites with sufficient historical records to identify their spatial continuity or transformation since 1980 were selected for adaptation-pattern classification. Standard deviational ellipse (SDE), kernel density estimation (KDE), and global and local spatial autocorrelation are employed to characterize their directional distribution, spatial concentration, and spatial association, while OPGD is used to evaluate the explanatory power and interaction effects of associated factors. Specifically, this study addresses three questions:

(1) What adaptation patterns have ritual spaces on Xiamen Island developed in response to urbanization?
(2) How do these patterns differ in their spatial distribution, orientation, clustering, and local spatial associations?
(3) Which urban factors are associated with these spatial differences, and how do these factors interact?

By integrating adaptation-pattern identification with intra-urban spatial analysis and multi-factor interaction detection, this study seeks to clarify the differentiated spatial responses of ritual spaces to urbanization and to provide an empirical basis for type-specific conservation and culturally sensitive urban renewal, with particular attention to ritual spaces facing spatial constraints in high-density built environments.

2. Materials and Methods

2.1. Study Area

This study focuses on Xiamen Island, located within Xiamen City of Fujian Province, southeastern China. Xiamen Island is the origin of Xiamen's urban development; in its early stages, the city's boundaries were primarily concentrated in the southwestern part of the island. According to statistics released by the Xiamen Municipal Bureau of Statistics, the urbanization rate of Xiamen's permanent resident population reached 91.31% in 2025, with the urbanization rates in Siming and Huli Districts on Xiamen Island both reaching 100% [25,26]. Xiamen has long been a region where folk beliefs thrive. The Chronicles of Xiamen, Volume 15: Records of Customs, states: "The land is dotted with shrines, and festivals and processions to welcome deities occupy nearly half the year" [27]. According to official statistics, in 2002, there were 1524 venues for folk religious activities with a floor area of 10 m^2 or more in Xiamen [28].

Therefore, this paper limits its scope of study to Xiamen Island (excluding Kulangsu) (Figure 1).

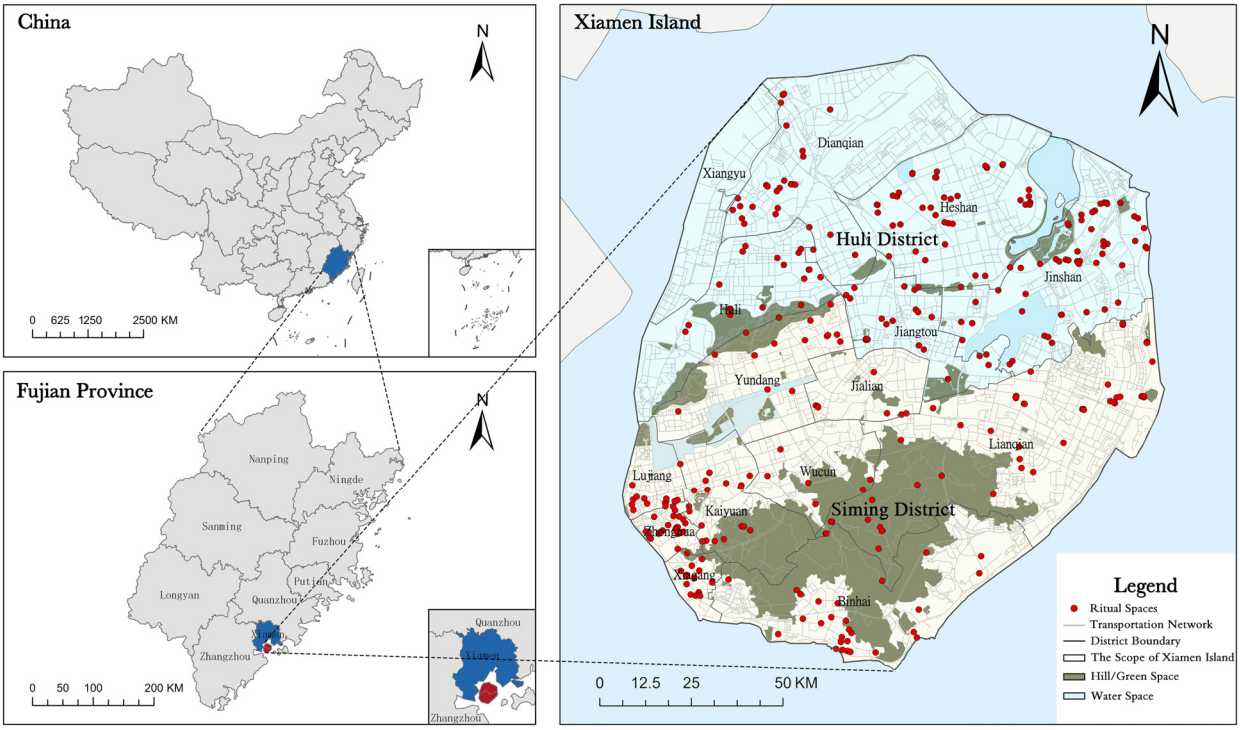


Figure 1. Location of the study area on Xiamen Island.

2.2. Data Sources

By consulting district gazetteers of Siming and Huli, local historical and cultural records, official planning documents, and media sources, and by cross-checking POI data with field surveys and interviews, a geospatial database of ritual spaces on Xiamen Island was established. Field surveys and interviews were conducted in December 2025, covering diverse urban settings, including the historic urban area (e.g., Xiamen City God Temple and Longzhu Temple), urban villages (e.g., Fuyuan Temple), and resettlement communities (e.g., Leixian Palace). The investigations focused on existing architectural configurations and the verification of reconstruction and relocation histories. After excluding sites that had disappeared or could not be reliably located, 353 extant ritual spaces were identified. Focusing on the impact of urbanization, this study takes 1980 as the starting point of the study period, based on the urban development history of Xiamen

Island. Among the 353 sites, 239 had sufficient historical records to identify their spatial continuity or transformation during the study period and were selected for adaptation-pattern classification and type-specific spatial analysis. The remaining 114 sites were excluded from classification because their documented reconstruction occurred before the study period or the available historical records were insufficient to reliably establish their initial spatial configurations and subsequent transformations. Accordingly, all 353 sites were used to examine the overall spatial distribution of extant ritual spaces, while the 239 classified sites were used to analyze adaptation patterns and their spatial characteristics. Associated factors were organized into three dimensions: spatial development intensity, population and economic activity, and policy intervention. Coordinates derived from Amap (GCJ-02) and Baidu Maps (BD-09) were first converted to WGS 84. All spatial datasets were projected to the WGS 1984 UTM Zone 50N coordinate system and subjected to geometric correction, outlier checking, and topological validation. Considering the close relationships between ritual spaces, local communities, and surrounding built environments, a relatively fine spatial scale was adopted to examine local variations in urban spatial conditions. Accordingly, a 500 m × 500 m regular grid was adopted as the basic analytical unit, and all associated factors were converted to the grid level to ensure consistency and reliability in spatial measurement and analysis.

The reconstruction and relocation histories of ritual spaces since 1980 were compiled to identify their spatial adaptation patterns. The associated factors, including population, building, POI, and planning data from different periods, were used to characterize the spatial conditions associated with the present distribution of these patterns. The data sources and processing procedures are summarized in Table 1.

Table 1. Data sources and processing methods.

Category	Subcategory	Data/Indicator	Year	Data Source	Data Processing
Ritual-Space Data	Existing Ritual Spaces	353 existing ritual spaces and their spatial locations	2026	District gazetteers of Siming and Huli [29]; local historical and cultural records [30–32]; official planning documents; media reports; POI data	Compiled, cross-checked, and field-verified. Individual ritual institutions were geocoded separately, with identical coordinates assigned to institutions sharing a building.
	Reconstruction History	239 ritual spaces with traceable reconstruction histories	1980–2026	Local gazetteers; historical and cultural records; field surveys; interviews	Reconstruction and relocation histories were traced for adaptation-pattern identification.

Table 1. *Cont.*

Category	Subcategory	Data/Indicator	Year	Data Source	Data Processing
Associated-Factor Data	Spatial Development Intensity	Floor Area Ratio (FAR)	2020	3D-GloBFP global three-dimensional building footprint dataset [33]	Building floor area was estimated by multiplying building footprint area by the estimated number of storeys, assuming an average storey height of 3 m. FAR was calculated as the ratio of the aggregated building floor area to the grid-cell area.
		Building Density	2020	3D-GloBFP global three-dimensional building footprint dataset [33]	Calculated as the proportion of building footprint area within each grid cell.
		Road Network Density	2025	Amap Open Platform API (https://lbs.amap.com)	Calculated from road-network length within each grid cell.
		Hill and Green-Space Density	2025	Baidu Maps imagery	Vectorized and calculated as area proportions within each grid cell.
	Population and Economic Activity	Population Density	2020	Street-level resident population data from the Seventh National Population Census [34]	Residential buildings were identified using residential land-use data and verified against imagery and POIs. Street-level census populations were allocated to grids based on estimated residential floor area.
		Commercial Facility Density	2025	Amap Open Platform API (https://lbs.amap.com)	POIs were selected from four Amap categories: sports and leisure services, catering services, shopping services, and financial services. The selected POIs were cleaned and aggregated within each 500 m × 500 m grid cell.
		Number of Residential Communities	2025	Amap Open Platform API (https://lbs.amap.com)	Residential-community POIs were counted within each grid cell.
	Policy Intervention	Urban Village Distribution	2023	Xiamen Village Spatial Control Plan (2021–2035)	Urban-village areas were extracted and overlaid with the analytical grid.
		Urban Renewal Coverage	2014–2024	"Regulations on Urban Renewal of the Xiamen Special Economic Zone"; "Conservation Plan for the Historic City of Xiamen; Xiamen Shantytown Redevelopment Plan (2015–2017)"; "Xiamen Village Spatial Control Plan (2021–2035)"	Renewal areas were integrated and spatially matched with the analytical grid.

2.3. Methods

2.3.1. Classification Framework for Ritual-Space Adaptation Patterns

Previous studies have documented various approaches to temple relocation and resettlement in southern Fujian, including multiple-temple consolidation, centralized resettlement, and vertical coexistence [35]. These practices provided a regional reference for examining the spatial adaptation of ritual spaces within the shared Minnan cultural context of Xiamen and Zhangzhou.

During urbanization, the preservation and reconstruction of ritual spaces have involved both on-site reconstruction and off-site relocation, giving rise to diverse architectural configurations and forms of spatial organization. Accordingly, drawing on historical records and field investigations, this study classified ritual-space adaptation patterns based on the independence of ritual buildings and sites, the spatial organization of multiple ritual institutions, and their integration with buildings serving other functions. Four adaptation patterns were identified: independent temple type, concentrated resettlement type, vertical integration type, and embedded type. The operational definitions and classification criteria for these patterns are presented in Table 2.

Table 2. Operational Definitions and Classification Criteria of Ritual-Space Adaptation Patterns on Xiamen Island.

Classification Category			Definition
With Independent Land Parcels	Independent Temple Type		The temple has its own land and buildings and retains the characteristics of a traditional single-structure temple
	Concentrated Resettlement Type	Consolidated Arrangement	Altars or ritual facilities of several smaller temples are incorporated into a principal temple building.
		Concentrated Clusters and Joint Temples	Multiple independent temples are grouped within a shared site, forming a spatially coordinated group while retaining their respective buildings and ritual identities.
Without Independent Land Parcels	Vertical Integration Type		The ritual space occupies a clearly identifiable floor or vertically organized spatial unit within a multi-storey building serving other functions.
	Embedded Type		The ritual space occupies a localized portion of a building serving other functions, without forming a distinct floor-level spatial unit.

2.3.2. Standard Deviational Ellipse

The Standard Deviational Ellipse (SDE) is a spatial statistical method used to summarize the central tendency, directional orientation, and spatial dispersion of geographic features through the mean center, major and minor axes, and rotation angle [36]. In this study, SDE was employed to compare the spatial distribution characteristics of ritual spaces associated with different adaptation patterns on Xiamen Island. The coordinates of the mean center are calculated as follows:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i, \bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \quad (1)$$

where x_i and y_i denote the coordinates of ritual space i, n is the number of ritual spaces, and $\overline{x}$ and $\overline{y}$ represent the coordinates of the mean center. The major and minor axes characterize the principal directions and degree of spatial dispersion, while the rotation angle indicates the dominant orientation of the distribution.

2.3.3. Kernel Density Analysis

Kernel Density Estimation (KDE) is a nonparametric statistical method that can visually represent the spatial distribution characteristics of point feature densities [37]. KDE was implemented in ArcGIS Pro (version 3.5.2) using the planar method, which is appropriate for local-scale analysis under a projected coordinate system. In this study, KDE was used to identify the concentration characteristics of ritual spaces associated with different adaptation patterns. The formula is as follows:

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right) \quad (2)$$

where $f(x)$ represents the estimated density of ritual spaces at location x; n is the number of ritual spaces; x_i denotes the location of ritual space i; h is the bandwidth controlling the degree of spatial smoothing; and $k(\cdot)$ is the kernel function. Higher estimated density values indicate areas where ritual spaces are more spatially concentrated, whereas lower values indicate relatively sparse distributions. The search radius (bandwidth) was set to 1500 m, with an output raster cell size of approximately 50 m.

2.3.4. Spatial Autocorrelation Analysis

Spatial autocorrelation analysis is used to characterize the degree of spatial association among the same attribute values of different observation objects [38], including global spatial autocorrelation analysis (Global Moran's I) and local spatial autocorrelation analysis (LISA). The former provides a comprehensive measure of spatial data across the entire study area to assess overall spatial distribution patterns; the latter is used to identify spatial heterogeneity and spatial hotspots and coldspots in local areas [39]. Local Moran's I is calculated as follows:

$$I_i = \frac{(x_i - \overline{x})}{m_0}\sum_{j=1}^{n} W_{ij}\left(x_j - \overline{x}\right) \quad (3)$$

where I_i denotes the Local Moran's I statistic for grid cell i; x_i and x_j represent the numbers of ritual spaces in grid cells i and j, respectively; $\overline{x}$ is the mean number of ritual spaces across all grid cells; W_{ij} is the spatial weight between grid cells i and j; and m_0 is the variance-related normalization term. Positive and statistically significant values of I_i indicate spatial clustering of similar values, corresponding to high–high (HH) or low–low (LL) clusters, whereas negative and statistically significant values indicate spatial outliers, corresponding to high–low (HL) or low–high (LH) associations. In this study, LISA was used to identify local clustering and spatial differentiation in the distribution of ritual spaces associated with different adaptation patterns on Xiamen Island. Both Global Moran's I and Local Moran's I were calculated in ArcGIS Pro using inverse-distance spatial weights based on Euclidean distance, with a distance threshold of 1500 m and row standardization. Statistical significance for Global Moran's I was evaluated using z-scores and p-values, while Local Moran's I was assessed using 999 random permutations.

2.3.5. Optimal Parameters-Based Geographical Detector

Geodetector (GD) comprises a set of statistical methods for detecting spatial stratified heterogeneity and evaluating the explanatory power of associated factors. They include four types of detectors: heterogeneity and factor detection, interaction detection, risk zone

detection, and ecological detection [16]. The discretization of spatial data is a fundamental issue; empirical parameters are typically selected, but this approach suffers from the limitations of subjective judgment in handling spatial data discretization. Song et al. developed the Optimal Parameters-based Geographical Detector (OPGD) method [22], which quantitatively determines the optimal parameter combination for spatial data discretization methods and the number of zones based on the magnitude of explanatory power (q-value). In this paper, using the R programming language, we employed equal-interval, natural breakpoint, quantile, geometric interval, and standard deviation classification methods, set the number of zones to 3–10 levels, determined the optimal parameter combinations, and conducted factor detection and interaction detection. This study employed the GD package within RStudio 4.3.2. A total of 632 analytical grid cells were used, with the actual land areas of clipped coastal cells used to calculate area-normalized indicators. The dependent variable was defined as the number of ritual spaces within each 500 m × 500 m grid cell. The overall analysis included all 353 extant ritual spaces, while the four type-specific analyses used the corresponding subsets of the 239 classified sites. All five OPGD analyses retained the same 632 grid cells, including those with zero counts. In the type-specific analyses, the dependent variable represents the number of ritual spaces of the corresponding adaptation type within each grid cell. Consequently, a high count of a particular type may also reflect a high overall concentration of ritual spaces within the cell.

The formula is as follows:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} \tag{4}$$

where L is the number of strata; N_h and σ_h^2 are the number of observations and the variance of the dependent variable within stratum h, respectively; and N and σ^2 are the number of observations and the variance of the dependent variable over the entire study area, respectively. The q value ranges from 0 to 1, with a larger value indicating greater explanatory power for spatial heterogeneity.

The optimal discretization methods and numbers of intervals selected for each influencing factor across all ritual spaces and the four adaptation types are presented in Table 3.

Table 3. Optimal Discretization Methods and Numbers of Intervals for Each Influencing Factor in the OPGD Analysis.

Influencing Factors	All Ritual Spaces	Independent Temple Type	Concentrated Resettlement Type	Vertical Integration Type	Embedded Type
Floor Area Ratio (FAR) (X1)	Equal interval/8	Quantile/8	Equal interval/7	Quantile/10	Quantile/10
Building Density (X2)	Quantile/6	Quantile/6	Quantile/10	Natural breaks/10	Natural breaks/10
Road Network Density (X3)	Quantile/9	Natural breaks/8	Quantile/10	Quantile/9	Natural breaks/9
Hill and Green-Space Density (X4)	Quantile/10	Quantile/10	Quantile/10	Quantile/9	Quantile/10
Population Density (X5)	Quantile/9	Quantile/9	Natural breaks/10	Natural breaks/10	Geometric interval/9
Commercial Facility Density (X6)	Equal interval/7	Quantile/8	Equal interval/7	Quantile/8	Geometric interval/7
Number of Residential Communities (X7)	Quantile/10	Geometric interval/5	Geometric interval/5	Quantile/10	Quantile/8
Urban Village Extent (X8)	Geometric interval/5	Geometric interval/5	Quantile/10	Quantile/10	Quantile/9
Urban Renewal Coverage (X9)	Quantile/7	Natural breaks/10	Quantile/8	Quantile/10	Quantile/7

2.4. Research Framework

This study develops a research framework integrating database construction, adaptation-pattern classification, spatial-pattern analysis, and explanatory-factor detection (Figure 2).

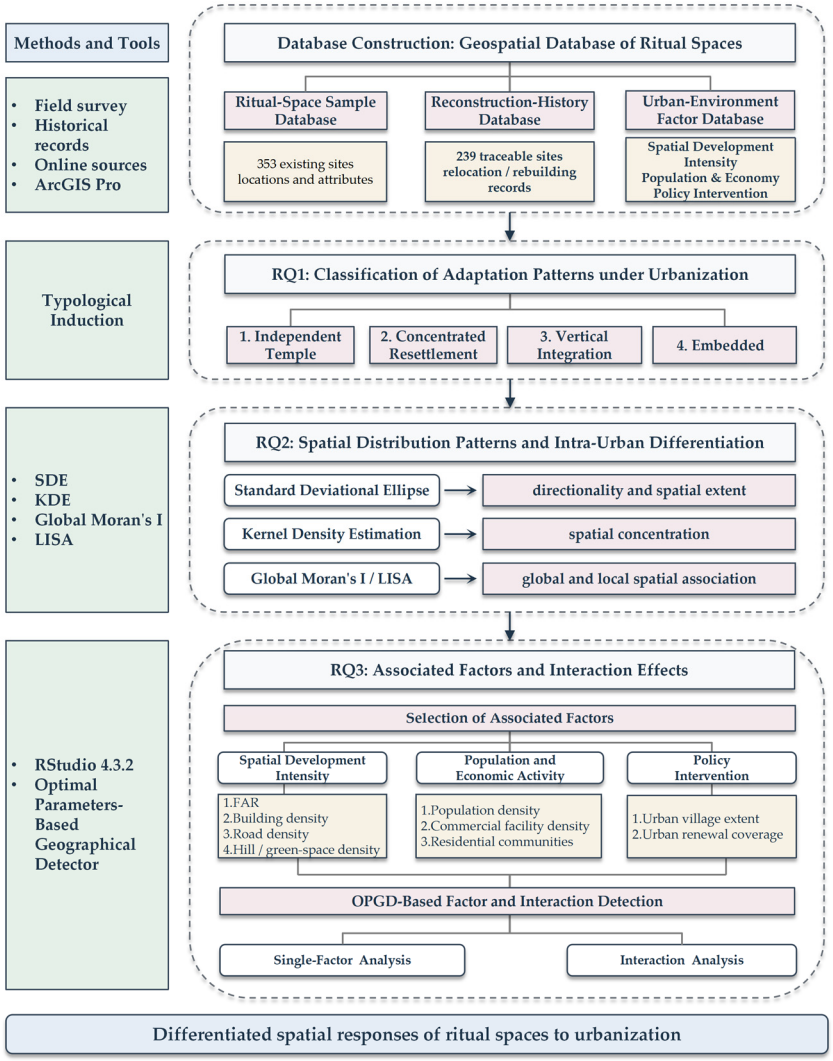


Figure 2. Research framework.

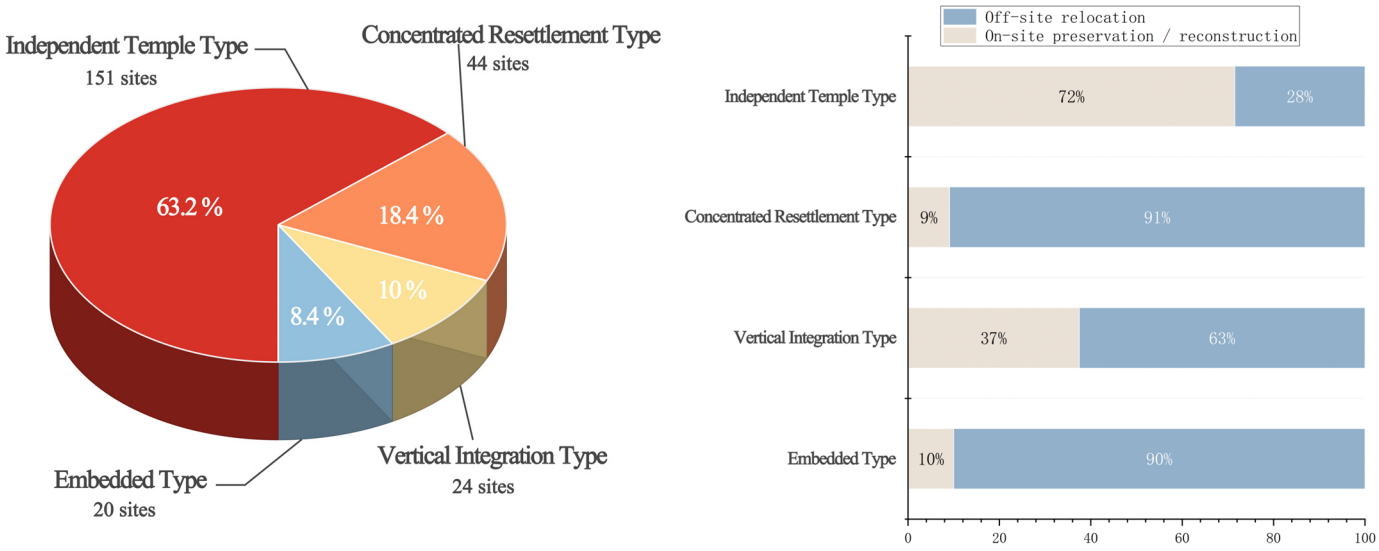
First, a geospatial database of ritual spaces on Xiamen Island was established through field surveys, historical records, online sources, and GIS processing. The database comprises 353 existing ritual spaces with location and attribute information, 239 sites with traceable relocation or reconstruction histories, and a set of urban-environmental factors representing spatial development intensity, population and economic activity, and policy intervention. Second, based on reconstruction histories and field investigation, the 239 traceable sites were classified into four adaptation patterns—independent temple type, concentrated resettlement type, vertical integration type, and embedded type—to address RQ1. Third, Standard Deviational Ellipse (SDE), Kernel Density Estimation (KDE), Global Moran's I, and Local Indicators of Spatial Association (LISA) were employed to examine the directionality, spatial extent, concentration, and global and local spatial associations of the different adaptation patterns, thereby addressing RQ2. Finally, the Optimal Parameters-based Geographical Detector (OPGD) was applied to evaluate the explanatory power of individual factors and the interaction effects among them, addressing RQ3. Through these sequential analyses, the framework identifies the differentiated spatial responses of ritual

spaces to urbanization and provides an empirical basis for understanding the relationships between ritual-space adaptation patterns and urban environmental conditions.

3. Results

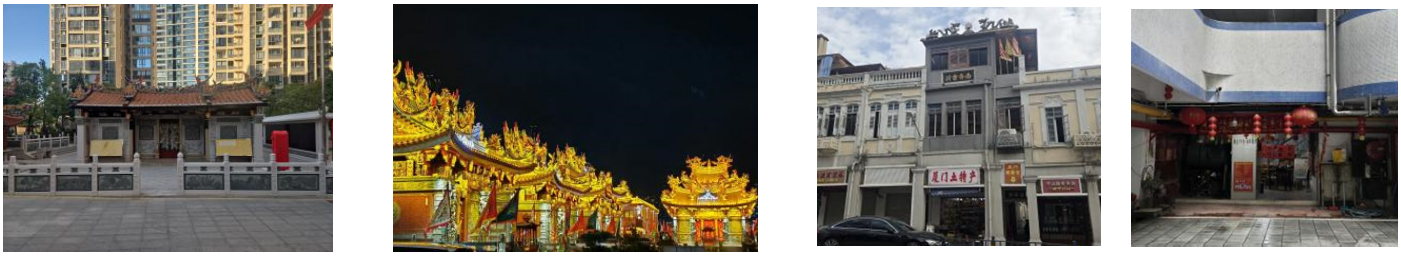
3.1. Classification of Ritual-Space Adaptation Patterns

As the urbanization process on Xiamen Island has involved a large number of "village-to-residential-community" conversions, new urban district developments, and old urban area renovations, existing communities, urban villages, and resettlement communities coexist. Under the pressure of urbanization, existing ritual spaces exhibit diverse spatial forms. Based on the classification criteria established in the methodology, the 239 ritual spaces were categorized into four adaptation patterns: independent temple type, concentrated resettlement type, vertical integration type, and embedded type. The independent temple type accounted for the largest proportion (63.2%), followed by the concentrated resettlement type (18.4%), the vertical integration type (10.0%), and the embedded type (8.4%). Regarding reconstruction status, 123 sites were preserved or reconstructed on-site, while 116 sites underwent off-site relocation; on-site preservation or reconstruction predominated in the independent temple type (72%), whereas off-site relocation was more common in the other three types (63–91%) (Figures 3 and 4).



(**a**) Proportions of the four adaptation patterns. (**b**) Reconstruction status by adaptation pattern.

Figure 3. Proportional Composition of the Four Ritual-Space Adaptation Patterns on Xiamen Island.



(**a**) (**b**) (**c**) (**d**)

Figure 4. Ritual spaces in four adaptive models. (**a**) Independent Temple: Xiao Family Ancestral Hall, (**b**) Concentrated Resettlement Type: Zhong Family Folk Culture Park, (**c**) Vertical Integration Type: Nanshou Palace, and (**d**) Embedded Type: Leixian Palace.

3.2. Spatial Differentiation of Adaptation Patterns

3.2.1. Spatial Morphological Characteristics

This study utilizes standard deviational ellipses (Table 4, Figure 5) to investigate the distributional characteristics of ritual spaces on Xiamen Island. In terms of directional distribution, ritual spaces on Xiamen Island predominantly follow a "southwest–northeast" orientation, with the center of mass of all ritual spaces located in the central part of the island, roughly at the boundary between Siming District and Huli District.

Table 4. Standard deviational ellipse parameters of ritual-space adaptation patterns.

Adaptation Type	Perimeter (km)	Area (km^2)	Mean Center Coordinates	Minor Axis (km)	Major Axis (km)	Azimuth (°)
Independent Temple Type	32.007	75.408	118.120 °E, 24.480 °N	3.893	6.167	41.787
Concentrated Resettlement Type	26.296	54.070	118.155 °E, 24.497 °N	3.723	4.623	61.745
Vertical Integration Type	24.902	27.158	118.113 °E, 24.476 °N	1.494	5.785	62.167
Embedded Type	22.011	30.091	118.101 °E, 24.480 °N	2.037	4.703	24.634

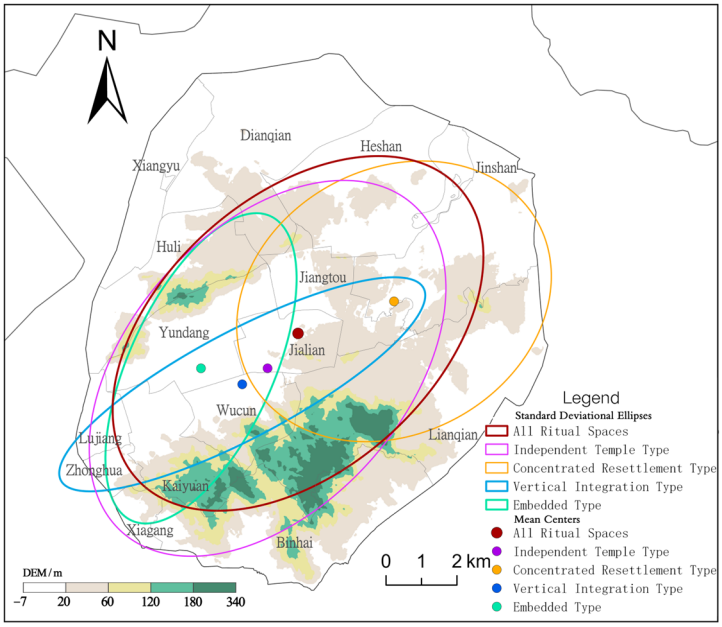


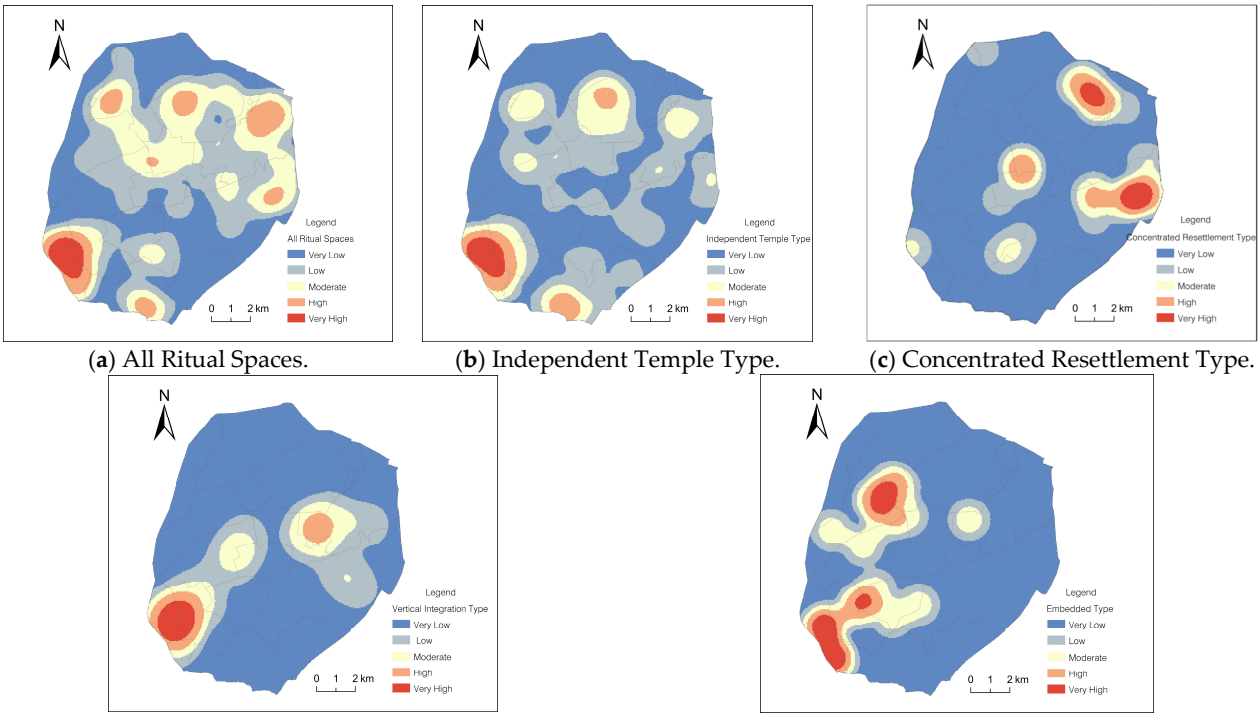
Figure 5. Standard deviational ellipses and mean centers of all ritual spaces and the four adaptation patterns on Xiamen Island.

Among the four types of ritual spaces: in terms of directional strength, the vertical integration type exhibits the greatest difference between its major and minor axes, indicating the strongest directional orientation and a distinct elongated distribution; the concentrated resettlement type's ellipse is relatively close to a circle, indicating weaker directionality, with its mean center located further northeast; the independent temple and the embedded types fall between the two in terms of directionality. In terms of spatial extent, the independent temple type has the largest elliptical area and a higher degree of dispersion; the concentrated resettlement type has a relatively smaller spatial extent, while the vertical integration and embedded types have the smallest elliptical areas, indicating more restricted spatial distributions. In terms of center-of-mass location, the mean centers for all types of ritual spaces are sequentially arranged along the "southwest–northeast" direction. Combined with the topographic background shown in Figure 5, these characteristics reflect the geographical configuration of Xiamen Island. Previous research has shown that the island's urban devel-

opment expanded from the southwestern old city toward the central, northern, and eastern areas, with terrain conditions and transportation development shaping this process [40]. The overall southwest–northeast orientation of ritual spaces is broadly consistent with this historical pattern of urban spatial expansion.

3.2.2. Spatial Aggregation Characteristics

Kernel Density Estimation (KDE) was employed to examine the spatial agglomeration patterns of ritual spaces on Xiamen Island (Figure 6). Overall, ritual spaces exhibit a spatial pattern characterized by "single-core agglomeration and multi-point clustering." The southwestern old city, particularly the Lujiang–Zhonghua–Xiagang area, forms the most prominent high-density core, while several secondary clusters occur in the central part of the island around Jiangtou and in the northern areas of Dianqian, Heshan, and Jinshan.



(**a**) All Ritual Spaces. (**b**) Independent Temple Type. (**c**) Concentrated Resettlement Type.

(**d**) Vertical Integration Type. (**e**) Embedded Type.

Figure 6. Kernel density distribution of all ritual spaces and the four adaptation patterns on Xiamen Island.

This spatial pattern is closely related to the historical development of Xiamen and the distribution of traditional communities. The old city retains a considerable number of community ritual spaces associated with long-established local groups. Its relatively high population mobility and mixed-surname residential structure have contributed to the formation of multiple ritual associations within individual communities. For example, communities such as Xiagang and Yingping contain multiple temple buildings. In contrast, ritual spaces in Huli District are predominantly community-based spaces rooted in former lineage villages.

The southwestern part of Siming District, including Lujiang, Kaiyuan, Zhonghua, and Xiagang Subdistricts, exhibits the greatest diversity of ritual-space adaptation patterns, with high-density areas of the independent temple type, embedded type, and vertical integration type occurring in close proximity. The independent temple type displays a "single-core and multiple-point" pattern, whereas the vertical integration type forms a pronounced high-density cluster primarily within the old city. The embedded type and concentrated

resettlement type both exhibit dual-core agglomeration. The concentrated resettlement type is mainly distributed around Lianqian and Heshan Subdistricts and shows an overall tendency to cluster toward the eastern and northeastern parts of Xiamen Island. Given that the concentrated resettlement type involves multiple ritual institutions sharing a common site, an additional KDE analysis was conducted by aggregating the 44 ritual institutions into 21 distinct sites to assess the potential influence of spatial co-location. Although local density patterns changed, the locations of the main concentrations in eastern and northeastern Xiamen Island remained largely unchanged, further supporting the regional clustering characteristics of this adaptation type.

3.2.3. Spatial Differentiation Characteristics

Building on the KDE results, spatial autocorrelation analysis was further employed to examine the statistical characteristics of spatial agglomeration and spatial heterogeneity. Global Moran's I was first calculated for all ritual spaces and for each adaptation type. As shown in Table 5, all Global Moran's I values are positive and statistically significant, indicating significant positive spatial autocorrelation in the spatial distributions of the overall ritual-space sample and the four adaptation types. Because the global index cannot fully characterize local spatial heterogeneity, Local Indicators of Spatial Association (LISA) were further applied to identify local clusters, spatial outliers, and heterogeneous areas (Figure 7). The results show that High–High (HH) clusters of ritual spaces are mainly located in the southwestern or northeastern parts of Xiamen Island. Low–Low (LL) clusters of all ritual spaces and the independent temple type are primarily distributed along the peripheral areas of the island, whereas no LL clusters are observed for the other three adaptation types. High–Low (HL) outliers occur sporadically across the study area, while Low–High (LH) outliers are generally distributed around the peripheries of HH cluster cores. These patterns indicate that some ritual spaces exhibit local spatial characteristics that differ from those of their surrounding areas.

Table 5. Results of the global spatial autocorrelation analysis of ritual spaces on Xiamen Island.

Type	Moran's I Index	z-Value	*p*-Value
All Ritual Spaces	0.139	11.774	$p < 0.001$
Independent Temple Type	0.167	14.175	$p < 0.001$
Concentrated Resettlement Type	0.058	5.224	$p < 0.001$
Vertical Integration Type	0.121	10.753	$p < 0.001$
Embedded Type	0.049	4.296	$p < 0.001$

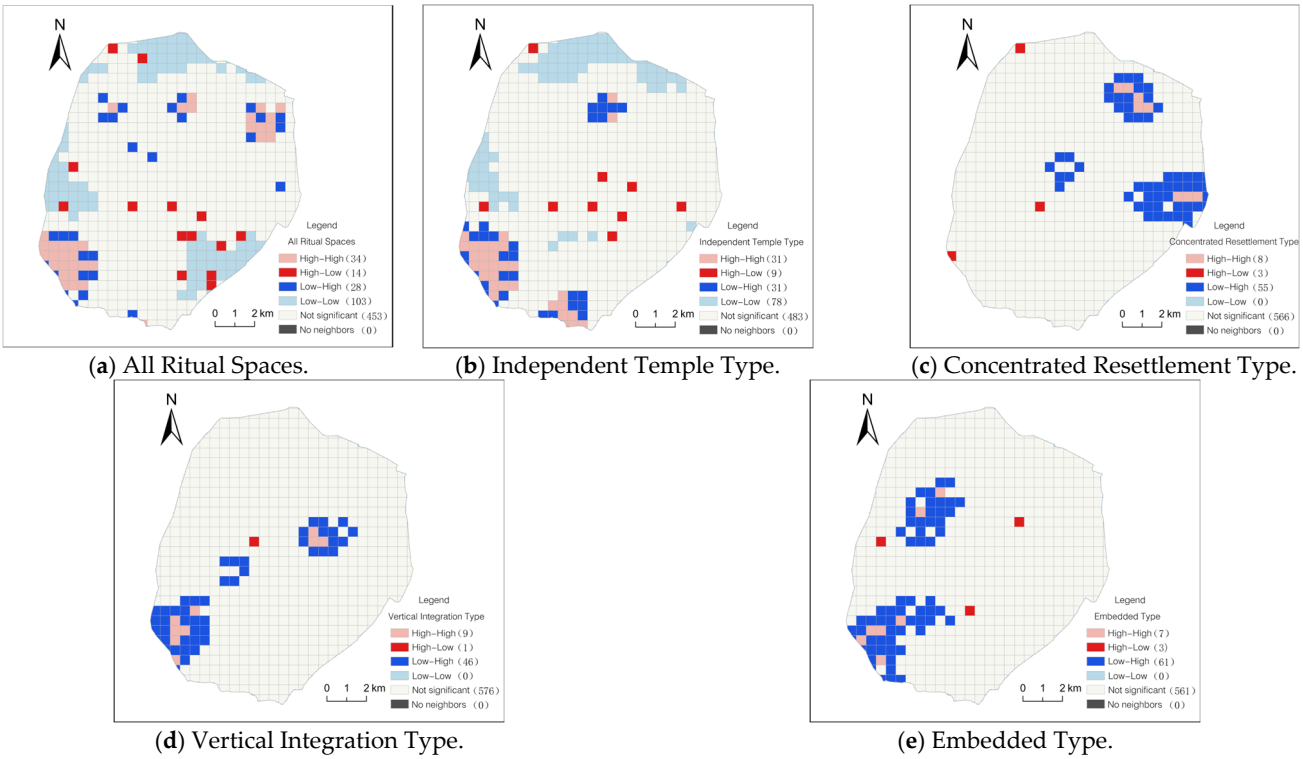
3.3. Influencing Factors of Spatial Differentiation and Interaction Effects

3.3.1. Selection of Influencing Factors

Based on previous studies of religious-space distribution, urban morphology, and urban redevelopment, nine explanatory factors were selected from three dimensions: spatial development intensity, population and economic activity, and urban renewal and policy intervention (Table 6). These factors were intended to capture the physical constraints imposed by the built environment, the socioeconomic demand generated by everyday urban activities, and the spatial restructuring effects of redevelopment and planning intervention.

Previous quantitative studies have shown that the distribution and transformation of religious places are jointly associated with built-environment characteristics, transportation accessibility, population concentration, economic activity, and environmental conditions [14,15,20,41]. Meanwhile, traditional community spaces such as urban villages provide an important spatial basis for the continuity of ritual practices and community networks, whereas urban redevelopment, demolition and resettlement, cultural governance, and planning intervention may directly

induce the preservation, relocation, integration, or reconstruction of ritual spaces [6,7,9,42]. Accordingly, an explanatory-factor framework encompassing spatial development, population and economic activity, and renewal intervention was constructed to examine the spatial differentiation of ritual-space adaptation patterns. To ensure horizontal comparability in spatial visualization, this paper uniformly adopts a five-level classification based on the natural breakpoint method for the visualization of influencing factors (Figure 8).



(**a**) All Ritual Spaces. (**b**) Independent Temple Type. (**c**) Concentrated Resettlement Type.

(**d**) Vertical Integration Type. (**e**) Embedded Type.

Figure 7. Local spatial autocorrelation (LISA) patterns of all ritual spaces and the four adaptation patterns on Xiamen Island.

Table 6. Influencing factors for ritual-space adaptation patterns.

Types	Influencing Factors	Unit	Rationale for Selection
Spatial Development Intensity	Floor Area Ratio (FAR) (X1)	-	Represents the intensity of land development [43]
	Building Density (X2)	-	Represents the proportion of land occupied by building footprints and reflects the availability of ground-level space [43]
	Road Network Density (X3)	km/km^2	Represents spatial connectivity and accessibility [44,45]
	Hill and Green-Space Density (X4)	-	Represents the spatial coverage of hills and green spaces, reflecting the natural and planned landscape characteristics of the urban environment.
Population and Economic Activity	Population Density (X5)	persons/km^2	Represents the degree of population concentration
	Commercial Facility Density (X6)	facilities/km^2	Represents the intensity of local economic activity
	Number of Residential Communities (X7)	count	Represents the concentration of residential community units

Table 6. *Cont.*

Types	Influencing Factors	Unit	Rationale for Selection
Policy Intervention	Urban Village Extent (X8)	-	Reflects the potential for ritual space preservation, relocation, and reorganization associated with urban-village redevelopment.
	Urban Renewal Coverage (X9)	-	Represents areas subject to planning intervention and spatial restructuring

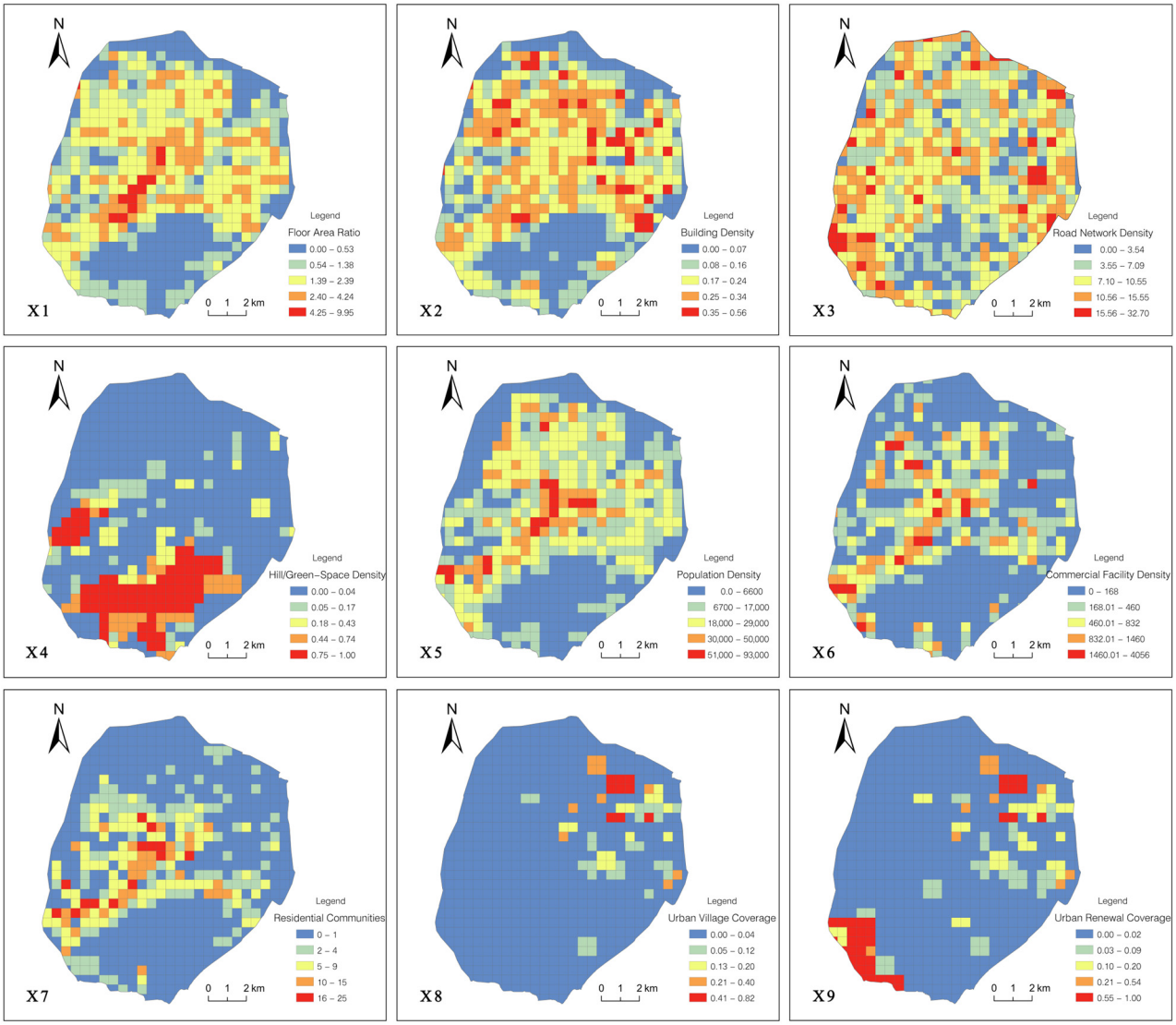


Figure 8. Spatial visualization of influencing factors for ritual space adaptation patterns on Xiamen Island.

3.3.2. Factor Detection Results

Factor detection was conducted to evaluate the explanatory power of influencing factors for the overall distribution of ritual spaces and the four adaptation types (Figure 9, Table 7). Most factor-detection results reached the conventional significance threshold ($p < 0.05$), while five results were not statistically significant. The explanatory power of individual factors was relatively limited, while their q-values reflected the relative strength of spatial associations between these factors and ritual-space distributions. Overall, among these factors, the scope of urban renewal coverage exhibited the strongest explanatory power,

approaching 0.15, while mountain green space density, population density, and building density made significant contributions to the pattern of ritual spaces, with explanatory power around 0.1.

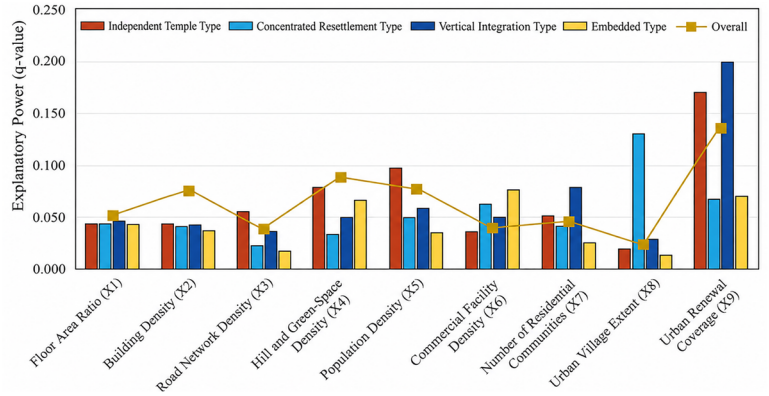


Figure 9. Explanatory power of influencing factors for all ritual spaces and the four adaptation types on Xiamen Island.

Table 7. Explanatory power and statistical significance of influencing factors for all ritual spaces and the four adaptation types on Xiamen Island (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

Influencing Factors	All Ritual Spaces	Independent Temple Type	Concentrated Resettlement Type	Vertical Integration Type	Embedded Type
Floor Area Ratio (FAR) (X1)	0.049 ***	0.038 **	0.040 **	0.043 **	0.039 **
Building Density (X2)	0.073 ***	0.040 ***	0.036 **	0.038 **	0.034 *
Road Network Density (X3)	0.035 **	0.052 ***	0.019	0.032 *	0.015
Hill and Green-Space Density (X4)	0.086 ***	0.076 ***	0.029 *	0.047 ***	0.063 ***
Population Density (X5)	0.076 ***	0.096 ***	0.046 **	0.055 ***	0.030 **
Commercial Facility Density (X6)	0.036 *	0.033 **	0.061 **	0.048 ***	0.072 ***
Number of Residential Communities (X7)	0.042 **	0.048 ***	0.037 ***	0.075 ***	0.022
Urban Village Extent (X8)	0.021 *	0.016 *	0.128 ***	0.028	0.010
Urban Renewal Coverage (X9)	0.134 ***	0.169 ***	0.065 ***	0.200 ***	0.068 ***

When comparing the explanatory power of various influencing factors, the following stood out:

(1) Urban village extent (X8) has substantially higher explanatory power for the concentrated resettlement type than for the independent temple type, vertical integration type, and embedded type. This spatial association may reflect the close relationship between concentrated resettlement sites and traditional village communities, where shared ritual practices and community ties provide an important social and spatial basis for the continued use and collective arrangement of ritual spaces.

(2) Urban renewal coverage (X9) ranks among the factors with the highest explanatory power across all four adaptation types. This suggests that urban renewal constitutes an important external force associated with the spatial distribution of different ritual-space adaptation types.

(3) The number of residential communities (X7) exhibits higher explanatory power for the vertical integration type than for the other three adaptation types. During urban-village redevelopment, residents are often relocated to resettlement communities, while ritual spaces may be transferred accordingly and incorporated into the ground floors or other levels of residential buildings, sometimes in combination with community public-service functions.

(4) Population density (X5) and hill and green-space coverage (X4) have relatively higher explanatory power for the independent temple type than for the other adaptation types. This suggests that the spatial distribution of independent temples is closely

associated with population concentration and local landscape conditions. Population concentration may provide a community base for sustained ritual activities, while hills and green spaces offer varied settings for the preservation and continuity of ritual spaces. Hilly terrain may limit intensive development, while urban parks and green spaces can also accommodate cultural practices and community activities, providing opportunities for the continued use and spatial reorganization of ritual spaces.

(5) The explanatory power of floor area ratio (X1) and building density (X2) varies little across the four adaptation types, with q-values generally around 0.05. This suggests that development intensity has relatively limited explanatory power for the spatial differentiation of ritual spaces across the four adaptation types. Rather, ritual spaces of different types are commonly exposed to spatial pressure and functional competition under intensive urban development.

(6) Commercial facility density (X6) has the strongest explanatory power for the embedded type, suggesting that this adaptation pattern is closely associated with commercially intensive urban areas. In such areas, limited space for independent ritual buildings may encourage the use of existing structures, allowing ritual activities to be accommodated within shop mezzanines, markets, or other commercial premises. This arrangement reflects how ritual spaces adapt to spatial constraints through the shared use of buildings with other urban functions.

3.3.3. Results of Interaction Analysis

The interaction detection results (Figure **??**) show that the spatial differentiation of ritual-space adaptation patterns is associated with the combined effects of multiple factors. In terms of interaction types, most factor combinations exhibit either nonlinear enhancement or bivariate enhancement. Across the 36 pairwise interactions examined for each adaptation type, nonlinear enhancement accounts for a relatively high proportion for the vertical integration type and embedded type (86.11% and 72.22%, respectively), indicating that their spatial differentiation is more strongly associated with complex interactions among multiple urban factors. By contrast, bivariate enhancement is more prevalent for the independent temple type and concentrated resettlement type (41.67% and 33.33%, respectively), indicating differences in the patterns of factor interactions across adaptation types.

(1) Independent Temple Type

For the independent temple type, population density ∩ urban renewal coverage (X5 ∩ X9, q = 0.236) exhibits the highest joint explanatory power, followed by urban renewal coverage ∩ road network density (X9 ∩ X3, q = 0.234) and urban renewal coverage ∩ floor area ratio (X9 ∩ X1, q = 0.223). Urban renewal coverage appears in all three leading interactions, with relatively similar q-values. These results highlight the combined spatial associations of independent temples with urban renewal policies, population activities, and surrounding built-environment conditions.

(2) Concentrated Resettlement Type

For the concentrated resettlement type, commercial facility density ∩ urban village extent (X6 ∩ X8, q = 0.205) exhibits the highest joint explanatory power, followed by urban renewal coverage ∩ population density (X9 ∩ X5, q = 0.180) and urban renewal coverage ∩ floor area ratio (X9 ∩ X1, q = 0.177). The interaction between urban village extent and commercial facility density is particularly notable, reflecting the spatial association of concentrated resettlement sites with urban villages and surrounding commercial activities. Meanwhile, the interactions involving urban renewal coverage indicate that the distribution of this type is also associated with population concentration and development intensity in areas covered by urban renewal.

(3) Vertical Integration Type

For the vertical integration type, the interactions among the examined factors generally exhibit relatively strong explanatory power. Among them, urban renewal coverage ∩ commercial facility density (X9 ∩ X6, q = 0.314) has the highest joint explanatory power, followed by urban renewal coverage ∩ population density (X9 ∩ X5, q = 0.280) and population density ∩ commercial facility density (X5 ∩ X6, q = 0.272). The three leading interactions involve pairwise combinations of urban renewal coverage, population density, and commercial facility density, indicating a relatively concentrated pattern of factor associations. These results suggest that, in the context of urban renewal, the spatial distribution of vertically integrated ritual spaces is closely associated with combinations of population density and commercial activities, consistent with their spatial organization through the integration of multiple functions within multi-storey buildings.

(4) Embedded Type

For the embedded type, floor area ratio ∩ road network density (X1 ∩ X3, q = 0.148) exhibits the highest joint explanatory power, followed by floor area ratio ∩ building density (X1 ∩ X2, q = 0.147) and urban renewal coverage ∩ commercial facility density (X9 ∩ X6, q = 0.143). Unlike the vertical integration type, the two leading interactions for the embedded type both involve floor area ratio, highlighting its combined associations with road network density and building density. These results indicate that the spatial distribution of embedded ritual spaces is closely related to built-environment intensity, consistent with their spatial characteristics of occupying localized areas within existing buildings, such as shop mezzanines and market premises.

3.4. Mechanisms Underlying Differentiated Adaptation of Ritual Spaces

Drawing on the spatial analysis results, historical records, and field investigations, the differentiated adaptation of ritual spaces can be examined from three interrelated perspectives: spatial development constraints, community demand, and policy intervention. Nanshou Palace, Zhong Family Folk Culture Park, and Leixian Palace were selected as representative cases to examine functional integration within buildings, concentrated resettlement during community redevelopment, and spatial readjustment following demolition, respectively. These representative cases provide supporting evidence for understanding how ritual spaces undergo spatial reconfiguration under different urban development conditions.

3.4.1. Spatial Constraints of Intensive Urban Development

Land resources on Xiamen Island are limited, and the urban space is compact. As spatial development intensity increases, some ritual spaces face constraints on independent land use and available building space, leading to vertical integration or accommodation within existing buildings. For example, after multiple rounds of urban expansion, the Nanshou Palace on Zhongshan Road in Siming District occupies the upper floor of a commercial building: the ground floor houses retail stores, the second floor accommodates a Nanyin music society, and the third floor accommodates ritual activities, forming a vertically integrated arrangement of commercial, cultural, and ritual functions. This spatial organization allows multiple functions to share limited building space. However, the upper-floor location and the entrance accessed through an alley within the arcade building weaken the temple's direct connection to the street and impose certain constraints on spatial visibility and the organization of ritual activities. The case illustrates how vertical integration accommodates ritual functions within compact urban environments while reshaping the relationships between ritual spaces, building functions, and surrounding public spaces.

3.4.2. Community Demand and Social Continuity

Ritual spaces serve as venues for clan or community groups to conduct ritual activities and maintain social networks; their selection and preservation have always revolved around the living spaces of the faith community. As urbanization has led to the demolition of villages and the relocation of residents to resettlement communities, some ritual spaces have been reorganized through nearby relocation, concentrated arrangements, or integration with community facilities. Zhong Family Folk Culture Park provides an example of this process. During the redevelopment of Zhong Family Village, several ritual sites formerly distributed throughout the village were relocated and arranged within a shared area, creating a concentrated spatial organization with shared land and public activity spaces. Compared with the relatively dispersed arrangement of ritual sites in traditional villages, this form of resettlement changes their relationships with residential buildings, roads, and public spaces while providing new settings for ritual activities associated with the original community. This case suggests that spatial adaptation during community restructuring involves not only the relocation of ritual buildings but also the reorganization of spatial relationships between existing community activities and newly developed residential environments.

3.4.3. Policy Intervention and Spatial Restructuring

Planning and policy regulations influence the preservation and spatial reconfiguration of ritual spaces through urban renewal, demolition and resettlement, and heritage conservation. The renovation of old villages involves the relocation and reconstruction of ritual spaces within the scope of villages and communities; some ritual sites are incorporated into folk culture parks through coordinated site allocation and concentrated resettlement. In contrast, due to the complex built environment and deep historical layers of old urban areas, spatial arrangements may involve in situ preservation, relocation, or temporary accommodation within existing buildings. The transformation of Leixian Palace illustrates the evolving nature of such arrangements. In 1998, its original building was demolished to accommodate urban development, after which ritual activities were relocated to a mezzanine space within Jinxiang Building. Although this arrangement allowed ritual activities to continue, the original spatial configuration of the independent temple could not be restored, and the site faced constraints related to spatial independence, integrity, and fire safety. In 2024, a relocation and restoration scheme for Leixian Palace was approved, with three independent buildings planned to accommodate ritual and related activities. This transition illustrates how the spatial arrangements of ritual sites may gradually shift from temporary accommodation toward more independent configurations as urban renewal and planning management evolve. The case demonstrates that ritual-space adaptation is not necessarily a one-time adjustment of building form but may involve successive spatial transformations associated with urban development and planning intervention.

4. Discussion

4.1. Main Findings

Taking Xiamen Island as a case study, this research, based on a multi-source geospatial database, employed spatial analytical methods, including the Standard Deviational Ellipse (SDE), Kernel Density Estimation (KDE), spatial autocorrelation analysis, and the Optimal Parameters-based Geographical Detector (OPGD), to identify the diverse adaptation patterns and spatial distribution characteristics of ritual spaces during urbanization and to examine the influencing factors associated with the spatial differentiation of ritual-space adaptation patterns and their interaction effects across three dimensions: spatial development intensity, population and economic activity, and policy intervention. The main conclusions are as follows:

1. Extant ritual spaces exhibit diverse forms of spatial persistence and reconfiguration during urbanization. Building on existing classifications of temple relocation and resettlement practices in Zhangzhou, this study refines the relevant categories by considering the architectural forms, independence of land parcels, and spatial organization of ritual spaces on Xiamen Island. Based on an inventory of 353 existing ritual spaces on Xiamen Island, four typical adaptation patterns were identified among the 239 sites with traceable reconstruction histories during the study period (since 1980): the independent temple type, concentrated resettlement type, vertical integration type, and embedded type. These patterns were further examined through comparative spatial analysis at the intra-urban scale. This approach provides further evidence of the applicability of existing regional classification practices in different urban contexts within southern Fujian and extends their typological application through spatial analysis.
2. Overall, ritual spaces exhibit a spatial pattern extending along a southwest–northeast direction, characterized by "single-core agglomeration and multi-point clustering." The different adaptation patterns show differences in spatial distribution, degree of agglomeration, and spatial differentiation.
3. The spatial differentiation of the four ritual-space adaptation types is associated with multiple influencing factors, and most factor combinations exhibit higher interaction q-values than the corresponding individual factors. Factor detection results show that the explanatory power of individual factors varies among different types of ritual spaces. In particular, urban renewal coverage (X9) exhibits the strongest or second-strongest explanatory power for all four types, reflecting the association between renewal-related spatial conditions and the present distribution of these adaptation types. Interaction detection results further show that the 36 pairwise factor combinations examined for each adaptation type are dominated by nonlinear enhancement and bivariate enhancement. For the independent temple, concentrated resettlement, vertical integration, and embedded types, nonlinear enhancement accounts for 52.78%, 63.89%, 86.11%, and 72.22% of the interactions, respectively, while bivariate enhancement accounts for 41.67%, 33.33%, 13.89%, and 25.00%, respectively. Although nonlinear enhancement predominates across all four types, it is particularly prevalent in the vertical integration and embedded types, indicating a higher prevalence of interaction effects exceeding the sum of the individual factors' explanatory power. In contrast, the independent temple and concentrated resettlement types exhibit relatively higher proportions of bivariate enhancement, reflecting a greater prevalence of interactions in which the combined explanatory power exceeds that of either individual factor.
4. Drawing on the spatial analysis results and representative cases, the differentiated adaptation of ritual spaces can be understood through the combined influence of spatial development constraints, community demand, and planning intervention. Spatial development intensity shapes the land-use and building-space conditions under which ritual sites are organized, encouraging some ritual spaces to adapt through vertical integration or accommodation within existing buildings. Community demand is closely associated with the living spaces of local ritual communities and influences the continued use, relocation, and concentrated arrangement of ritual sites during residential relocation and community restructuring. Planning interventions, through specific decisions concerning preservation, relocation, and spatial allocation during urban renewal, directly influence the siting and reconfiguration of ritual spaces and undergo dynamic adjustments throughout successive stages of urban development and renewal. These three dimensions interact in the process of urban spatial transformation, giving rise to differentiated pathways of ritual-space adaptation.

4.2. Planning Implications

The four adaptation patterns identified in this study illustrate how existing ritual spaces have adapted to changes in the urban built environment through different forms of spatial reconfiguration. The conservation of ritual spaces in urban renewal should move beyond static preservation at the material level toward a sustainable pathway emphasizing functional revitalization and community integration. Based on the formation mechanisms and spatial characteristics of different ritual-space adaptation patterns, differentiated conservation and guidance strategies should be implemented in urban renewal.

For the independent temple type, in situ conservation and management of the surrounding environment should be prioritized according to the historical and cultural value and existing conditions of each site. For the concentrated resettlement type, spaces for folk activities should be reserved in renewal-unit planning and the construction of resettlement communities to ensure the continuity of traditional community culture. For the vertical integration type and embedded type, attention should be given to spatial configuration, functional coordination, and accessibility within mixed-use buildings to accommodate ritual activities. These strategies should also consider the needs and preferences of local ritual communities through consultation, ensuring that spatial arrangements remain compatible with ritual practices.

Compared with previous studies, the contributions of this study are twofold. First, it refines the classification of ritual-space adaptation patterns and identifies different ways in which ritual spaces on Xiamen Island have persisted through urbanization, providing a typological analytical framework for their conservation. Second, by integrating this classification with intra-urban spatial analysis and the established Optimal Parameters-based Geographical Detector (OPGD), the study compares how built-environment and planning conditions are associated with the distributions of the four adaptation types.

This study also has several limitations. First, the analysis focuses on existing ritual spaces, and the exclusion of disappeared sites and those without sufficient historical records may introduce sample selection bias. The 239 classified ritual spaces are concentrated in the southwestern historic urban area, whereas the 114 unclassified sites are mainly clustered in the northern, northeastern, and north-central parts of Xiamen Island (Figure S1). This geographical imbalance may limit the representation of northern areas in the type-specific analyses. Second, the use of cross-sectional urban data limits the understanding of long-term changes in the spatial relationships between ritual-space adaptation patterns and urban conditions. Future research could incorporate historical spatial datasets to further examine how these relationships evolve during urbanization. Third, because some factors are difficult to quantify, variables such as the degree of residents' religious belief and community cultural identity were not incorporated into the influencing-factor indicator system, resulting in an incomplete measurement of the social-demand dimension. In addition, the use of a 500 m × 500 m analytical grid may also introduce scale-dependent effects, potentially influencing the identified spatial patterns and OPGD results. The OPGD results may be sensitive to discretization choices, while spatial autocorrelation may affect the statistical significance of factor detection. Future research could further integrate questionnaire surveys and community interviews to establish an evaluation framework combining subjective and objective factors, and conduct sensitivity analyses across different analytical grid scales and discretization schemes, alongside spatially informed significance tests, to assess the robustness of the spatial analysis and OPGD results. Such efforts could provide a scientific basis for the inheritance of Minnan culture and for maintaining a spatial quality in which tradition and modernity coexist under the highly urbanized conditions of Xiamen.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/buildings16234755/s1, Figure S1. Comparison of the spatial distributions of unclassified and classified ritual spaces on Xiamen Island.

Author Contributions: Conceptualization, Z.L. and S.L.; methodology, Z.L., S.L. and C.H.; software, S.L.; formal analysis, S.L.; investigation, S.L. and C.H.; data curation, Z.L. and S.L.; resources, Z.L.; visualization, S.L.; writing—original draft preparation, S.L. and Z.L.; writing—review and editing, Z.L., S.L., C.H. and Y.Y.; supervision, Z.L. and Y.Y.; validation, Z.L. and Y.Y.; project administration, Y.Y. and Z.L.; funding acquisition, Z.L. and Y.Y. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study primarily involved architectural field investigations and interviews with temple management personnel to verify historical information concerning the relocation and reconstruction of ritual spaces. The interviews did not involve the collection or analysis of personal beliefs, health information, or other sensitive personal data. No identifying information about interviewees is disclosed. Formal ethical approval was not required.

Informed Consent Statement: Verbal informed consent was obtained from the interviewees prior to their participation. The research purpose was explained in advance, and participation was voluntary. The interviews focused on the verification of non-sensitive historical information, and the identities of interviewees are not disclosed.

Data Availability Statement: The source data used in this study are publicly available from the sources cited in the article. The processed ritual-space database and derived spatial datasets are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

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