Priority Sequencing and Pathway Identification for the Digital Activation of Lingnan Architectural Heritage in Small and Medium-Sized Cities

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Abstract. As a representative resource-constrained small and medium-sized city in northern Guangdong within the Lingnan region, Qingyuan faces a core challenge in heritage digital twin deployment that is not technical feasibility itself, but how to determine which heritage units should receive priority investment and where first-round implementation should begin. Taking Qingcheng District as the study area, this paper uses 364 heritage-related POIs and 15 representative cases to build a prioritization framework for the digital activation of Lingnan architectural heritage through GIS, AHP, and TOPSIS. The results show that Qingcheng's Lingnan architectural heritage is core-clustered yet overall dispersed. In the overall priority sequence, Zhongshan Park, the Qingyuan County Revolutionary Martyrs Monument, and Qingyuan Tourism, Culture, and Shopping Street rank highest. The 15 cases indicate three primary pathways—digital archive, digital narrative, and digital governance—corresponding to different implementation focuses. The study suggests that small and medium-sized cities should not pursue simultaneous, full-coverage, high-investment digital twin rollout. Instead, they should first identify a defensible priority sequence and then use the pathway result to guide initial implementation. Relative closeness should therefore be interpreted not as an absolute judgment of heritage value, but as a relative order for resource allocation.

Keywords: digital twin; Lingnan architectural heritage; small and medium-sized cities; priority sequence; GIS; AHP; TOPSIS

1 INTRODUCTION

In recent years, research on digital twin cities has moved from proof-of-concept and three-dimensional representation toward practical applications in planning regulation, urban governance, and operational optimization [1-3]. In the field of cultural heritage conservation, the research focus has likewise shifted from whether heritage can be digitally modeled to how completed models can support archival organization, conservation monitoring, public communication, and institutional coordination [4-7]. Within the broader agenda of digital governance, historical-cultural conservation, and urban renewal, this shift carries both theoretical significance and practical relevance.

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For Qingyuan and other Lingnan small and medium-sized cities in northern Guangdong, however, the core issue extends far beyond the technical feasibility of a digital twin workflow. Strong digital development gradients persist within Guangdong: core cities are better positioned to absorb the high costs of platform construction, long-term operation, and multi-source data integration, whereas cities such as Qingyuan face simultaneous constraints in fiscal capacity, technical staffing, and the spatial dispersion of heritage sites. The most urgent practical question is therefore not whether every heritage object can be turned into a digital twin, but which heritage units should be prioritized for digital-twin activation and from which direction the first round of implementation should begin.

The distribution of heritage in Qingcheng District is highly representative. Lingnan architectural heritage there does not form a continuous historic quarter; instead, it is discretely embedded in the modern built-up area and spans diverse types. Some heritage units are better suited to early digital archiving and long-term retention, some to public-facing digital narrative interfaces, and others to integration into everyday urban management, event organization, or community services. For Qingcheng, the essence of digital-twin activation lies in the rational sequencing and efficient allocation of limited resources rather than in technology display for its own sake.

Against this practical background, the study focuses on a concrete question: which heritage units should be advanced first, and how should they be advanced? Using 364 heritage-related POIs in Qingcheng District as the overall spatial sample and 15 representative cases as the decision set, the paper combines GIS-based evidence extraction, AHP weighting, and TOPSIS ranking within a fixed evaluation framework to identify the first-round priority objects for digital-twin activation and indicate each case's primary pathway under the fixed framework.

2 Literature Review

In recent years, scholarship on heritage digital twins has gradually moved beyond the technical limits of geometric modeling and visualization toward data integration, semantic description, life-cycle monitoring, and management-oriented systems [4-7,15]. This development indicates that the core value of heritage digital twins no longer lies merely in digitally reconstructing the physical form of heritage, but in integrating archives, value interpretation, dynamic monitoring, and operational logic into a controllable and optimizable information system. At the same time, research on living heritage has broadened the dimensions through which heritage value is assessed. A growing body of work shows that the significance of heritage derives not only from its static historical value as a monument, but also from its continuing functions, community attachments, and everyday interaction scenarios [8-10]. This perspective is highly compatible with Lingnan architectural heritage, much of which remains deeply embedded in community life and neighborhood activity and therefore cannot be adequately assessed through the standards used for purely static monuments.

In practical decision-making on heritage conservation and activation, multi-criteria evaluation offers a scientifically defensible analytical framework whenever planners

must simultaneously consider cultural value, spatial accessibility, activation potential, and implementation conditions [11-14]. This is especially important for resource-constrained small and medium-sized cities, where the key issue is not whether a single heritage object deserves protection, but how to establish a reasonable sequence of action when only part of the heritage stock can be advanced first.

Taken together, the major research gap does not lie in the further refinement of heritage digital twin technology itself, but in the scientific determination of deployment order under resource constraints. Existing studies emphasize technical capability, platform construction, and possible application scenarios, while work on heritage renewal and value assessment often remains at the level of general priority rankings or broad strategic suggestions. For small-city practice, however, the central question is not how to realize full-coverage digital twins for all heritage objects, but which objects should be advanced first and on what grounds when simultaneous rollout is impossible. Without a clear and defensible deployment order, local practice readily falls into two inefficient patterns: either limited resources are spread thinly across all heritage objects, leaving each with only superficial digitalization and little real activation, or investment is concentrated only on the most symbolic sites, overlooking those with greater potential for public access, narrative diffusion, or governance embedding. Moreover, existing studies usually stop at ranking output and rarely connect ranking with pathway identification, meaning that even when local governments obtain an order list, they still lack guidance on where first-round resources should be focused.

3 Research Gap, Questions, and Contributions

3.1 Research Gap

Three gaps define the present study. First, existing heritage digital twin research focuses more on technical capability and feasibility than on priority deployment in practical operations and does not adequately respond to the realities of resource-constrained small and medium-sized cities. Second, living value and community-embedded value are widely acknowledged but have not been robustly incorporated into a framework for identifying priority sequence in heritage digital-twin activation. Third, existing research often produces ranking results without translating them into actionable first-round implementation directions, creating a gap between academic output and local practical needs. For Lingnan small and medium-sized cities, these three gaps jointly hinder effective answers to a concrete question: which heritage units should be prioritized under limited resources, and from which direction should implementation begin?

If this question cannot be answered directly, small cities are left with only two choices in heritage digital twin practice: either distribute limited investment thinly across all heritage objects and leave every case at a shallow level of digitalization, or concentrate resources on a few highly symbolic nodes while neglecting those more capable of generating public reach, narrative circulation, or governance embedding. The study therefore treats priority ranking not as the endpoint of analysis but as a basis for first-round action judgment and links it to pathway identification in order to increase practical value.

3.2 Research Questions

- RQ1: Which Lingnan architectural heritage units should be prioritized for inclusion in the digital-twin activation sequence in the context of Lingnan small and medium-sized cities?
- RQ2: How is this priority sequence jointly shaped by archival value, activation potential, and twin-scenario carrying capacity?
- RQ3: How can ranking results be translated into pathway-oriented implementation logic rather than remain a simple order list?

3.3 Contributions

The first contribution of this paper is to define heritage digital-twin activation in small and medium-sized cities as a problem of priority sequencing, rather than to assume a digital starting point that can cover all heritage objects simultaneously. The research focus is therefore not whether digital twin technology deserves to be promoted in general, but why prioritization is necessary under resource constraints instead of a blind pursuit of comprehensive digitalization. Second, the paper converts living value and community-embedded value from general statements into evaluation indicators that can enter multidimensional comparison. By bringing transport accessibility, surrounding activity support, public cognition and narrative potential, and governance embeddedness into one framework, heritage objects are assessed not as static cultural stock but within real community interfaces and contemporary use scenarios, thereby improving both the analytical rigor and the practical relevance of the evaluation system. Finally, the added value of the paper lies not only in producing a priority sequence for heritage digital-twin activation, but also in translating that sequence into primary pathway judgment. Without introducing an additional evaluation model or extra threshold, the study uses relative closeness to identify priority order and then treats the relative advantage among the three criterion dimensions as an initial assignment heuristic for indicating each case's primary pathway and implementation focus. This makes the results more compatible with local government project scheduling and resource allocation in practice.

4 Study Area, Data, and Method

4.1 Study Area and Lingnan Contextual Relevance

The study area is Qingcheng District, Qingyuan City, Guangdong Province. The district contains multiple types of Lingnan architectural heritage, including commemorative facilities, religious buildings, parks and green spaces, characteristic commercial streets, and clan-based heritage nodes, but it does not form a single continuous historic quarter. This spatial pattern, in which heritage is discretely embedded in the modern built-up area, makes Qingcheng an appropriate case for examining how heritage digital-twin activation can be organized in ordinary urban space.

Qingcheng also exhibits the typical features of Lingnan small and medium-sized

cities. It is located within Guangdong's relatively advanced digital environment, yet it does not possess the fiscal resources or project maturity of metropolitan cores. Its Lingnan architectural heritage is both a local cultural stock and a set of community public spaces still in active everyday use. The analytical logic of this paper addresses one governance question through an integrated chain of spatial evidence extraction, weight assignment, priority ranking, and primary pathway identification, as shown in Fig. 1.

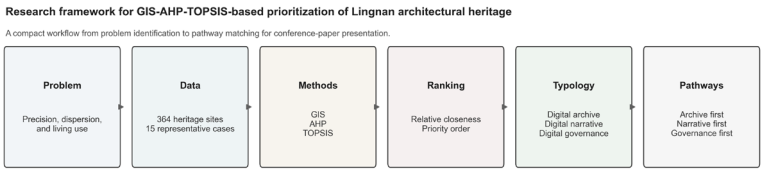

Fig. 1. Research framework.

4.2 Data and Case Selection

The study uses data at two levels. The first level consists of 364 heritage-related POIs in Qingcheng District, which are used to identify the overall spatial pattern of heritage and the supporting conditions around it. The second level consists of 15 representative cases selected as the core comparison set for the subsequent AHP-TOPSIS evaluation. This layered design clearly distinguishes between overall spatial-pattern identification and first-round deployment comparison and thereby improves analytical precision and rigor.

The 15 representative cases are not the result of random sampling but a systematically screened comparison set drawn from heritage-related objects in Qingcheng. Four principles guided case selection. The first is type coverage, so that four major heritage scenarios are represented: historical commemoration, religious belief, characteristic commerce, and landscape heritage. The second is spatial balance, meaning that both core clusters and discretely embedded nodes are included to avoid concentration in a single location. The third is functional fit: cases still in use were preferred so that the three potential implementation directions of digital archive, digital narrative, and digital governance could all enter the comparison set. The fourth is data availability: each case had to have a clear location, extractable surrounding-environment information, and basic evaluation materials so that GIS-based evidence extraction and subjective scoring could be implemented on the same scale. Anchored in the broader background of 364 POIs, these 15 cases serve a multi-criteria comparison for first-round deployment rather than a statistical inference about the entire heritage population.

4.3 Indicator Framework

The study adopts nine evaluation indicators organized into three core judgment dimensions so as to cover the principal factors affecting heritage digital-twin activation. B1

corresponds to archival value and asks whether a heritage object should receive priority in digital archiving and long-term retention. B2 corresponds to activation potential and measures the strength of the object's connection with urban activity networks and the feasibility of living use. B3 corresponds to twin-scenario carrying capacity and evaluates whether the object can be rapidly connected to urban management, public services, or multi-actor coordination scenarios. These three dimensions are sufficient to answer two central questions: which heritage units should enter the digital-twin activation sequence first, and from which direction should implementation begin once they are selected?

The indicator system does not compress heritage value into a single cultural grade. Instead, it places retention necessity, urban access conditions, and implementation carrying capacity within one comparative framework to achieve a multidimensional and comprehensive evaluation. Only when these three aspects match well can a heritage unit move forward in the priority sequence and acquire practical relevance for first-round deployment. In comparative terms, B1 addresses whether a heritage object should be retained first and answers the question of what should be preserved. B2 addresses whether a heritage object can be activated first and answers the question of how living use can be realized. B3 addresses whether a heritage object can be connected to governance first and answers the question of how implementation can be grounded. The three dimensions emphasize different issues, do not replace one another, and together constitute a complete evaluative logic.

In first-round deployment assessment, B2 (activation potential) receives the greatest weight because limited resources are usually directed first toward heritage units that can more readily generate public reach and value diffusion, which accords with the practical needs of small and medium-sized cities. Yet B1 (archival value) and B3 (twin-scenario carrying capacity) remain indispensable. Without B1, heritage nodes with a high need for archiving may be crowded out by short-term activation logic and fail to be properly retained. Without B3, heritage units with governance interfaces cannot be distinguished from objects suited only to display and therefore cannot support a deeper integration of digital twins with urban governance.

The full indicator system and weight structure are presented in Table 1.

Table 1. Indicator system and weight structure

Criterion layer	Criterion weight	Indicator	Local weight	Global weight	Data source / scoring rule
B1 Archival value	0.3035	C1.1 Historical value	0.4016	0.1219	Graded according to protection level or historical importance.
		C1.2 Artistic value	0.4016	0.1219	Graded according to architectural form, decorative features, and representativeness.
		C1.3 Scientific value	0.1969	0.0597	Graded according to the rarity of structure, materials, or type.
B2 Activation potential	0.4991	C2.1 Accessibility	0.2764	0.1379	GIS bus/public transport accessibility analysis.

Criterion layer	Criterion weight	Indicator	Local weight	Global weight	Data source / scoring rule
		C2.2 Spatial clustering	0.1832	0.0914	GIS kernel-density sampling.
		C2.3 Surrounding business support	0.1780	0.0888	GIS buffer analysis of active POIs in culture, tourism, commerce, catering, and related uses.
		C2.4 Public cognition/narrative potential	0.3624	0.1809	Graded according to local recognition, local records, and narrative potential.
B3 Twin-scenario carrying capacity	0.1974	C3.1 Multi-scenario fit	0.5000	0.0987	Graded according to fit with guiding, events, environmental management, and related scenarios.
		C3.2 Governance embeddedness	0.5000	0.0987	Graded according to clarity of governance interfaces, community basis, and feasibility of platform access.

Note: The evaluation framework comprises nine indicators, including C1.1-C1.3, C2.1-C2.4, and C3.1-C3.2. B1, B2, and B3 correspond to archival value, activation potential, and twin-scenario carrying capacity, respectively.

For key subjective indicators, the study uses five-point rubrics for historical value, public cognition and narrative potential, and scenario-carrying indicators. Table 2 provides an operational note for how these indicators are interpreted in the case comparison.

Table 2. Five-point rubrics for key subjective indicators.

Indicator	Five-point rubric
C1.1 Historical value	High scores indicate a higher protection level or a clearly defined local historical anchor; medium scores indicate clear local memory but a narrower sphere of influence; low scores indicate weak historical anchoring or limited recognizability.
C1.2 Artistic value	High scores indicate strong representativeness in architectural form, decoration, or visual character; medium scores indicate some distinctiveness but only moderate representativeness; low scores indicate weak formal characteristics or limited recognizability.
C1.3 Scientific value	High scores indicate strong rarity in structure, materials, or type; medium scores indicate some research value; low scores indicate limited rarity and weak research discernibility.
C2.4 Public cognition/narrative potential	High scores indicate stable local recognition and a clear narrative line; medium scores indicate some recognition base but limited narrative extensibility; low scores indicate weak public recognition or insufficient narrative clues.
C3.1 Multi-scenario fit	High scores indicate the ability to support guiding, display, events, or environmental management at the same time; medium scores indicate fit with a limited number of scenarios; low scores indicate a relatively narrow scenario range.
C3.2 Governance embeddedness	High scores indicate a clear governance interface and easy linkage with communities or platforms; medium scores indicate an interface is present but collaborative conditions are average; low scores indicate vague interfaces or a weak basis for coordination.

Note: Table 2 presents the five-point rubrics used as an indicative scoring note for the subjective indicators in the case comparison.

4.4 GIS-Based Spatial Evidence Extraction

In this study, GIS is used in two main ways. For the 364 heritage-related POIs, GIS spatial analysis is employed to identify distribution patterns and kernel-density characteristics, thereby clarifying the clustering and dispersion of heritage across the district. For the 15 representative cases, GIS is used to obtain objective data for C2.1 (accessibility), C2.2 (spatial clustering), and C2.3 (surrounding business support), providing direct input for the comprehensive evaluation. These three indicators capture different evaluative aspects: threshold of access, locational advantage within the heritage network, and the intensity of nearby support conditions.

The specific scoring rules are as follows. C2.1 is calculated from the distance between a case and its nearest public transport node. Walking time t is estimated at 1.2 m/s and mapped to scores of 5, 4, 3, 2, and 1 according to the intervals $t <= 5$ min, $5 < t <= 10$ min, $10 < t <= 15$ min, $15 < t <= 20$ min, and $t > 20$ min. C2.2 converts kernel-density sampling values into high, medium, and low classes using the Natural Breaks method and maps them to 5, 3, and 1 points, respectively. C2.3 groups the proportion of active support POIs within a 500 m buffer into quintiles across the 15 cases and maps the lowest 20%, 20%-40%, 40%-60%, 60%-80%, and highest 20% to 1-5 points. All three indicators are first derived from GIS and POI analysis as raw data and are then converted into standardized case-level inputs for TOPSIS to ensure comparability. Taken together, C2.1 addresses the difficulty of reaching a heritage unit and reflects the convenience of public access. C2.2 addresses the position of a heritage unit within the broader heritage network and reflects its spatial clustering advantage. C2.3 addresses whether the surrounding environment provides sufficiently active support for display, consumption, or event linkage and therefore reflects the environmental basis for living use.

4.5 AHP Weighting

The study uses the Analytic Hierarchy Process (AHP) to determine indicator weights. Specifically, revised judgment matrices from six experts are aggregated through the geometric mean. All consistency tests passed, with CI values below 0.018. The criterion-layer weights are B1 = 0.3035, B2 = 0.4991, and B3 = 0.1974, and the global weights of the nine indicators are determined from the final calculations. Among them, C2.4 (public cognition/narrative potential) has the highest weight (0.1809), followed by C2.1 (accessibility) at 0.1379, while C1.1 (historical value) and C1.2 (artistic value) both equal 0.1219. These results indicate that activation potential plays the dominant role in the first-round deployment of heritage digital twins in small and medium-sized cities, while archival value and twin-scenario carrying capacity still contribute independently and materially to priority identification.

4.6 TOPSIS Ranking and Pathway Identification

The TOPSIS method serves two purposes in this study. First, it uses relative closeness to generate a continuous ranking of the 15 representative cases and thereby identify

which heritage units should be prioritized for inclusion in the digital-twin activation sequence. Second, it compares the relative advantages of the three criterion dimensions B1, B2, and B3 to indicate each case's primary pathway.

Priority ranking and pathway identification are treated separately because case rank and implementation direction do not fully coincide. Cases with high rank may still require different initial directions, and cases within the same pathway must still be ordered by relative closeness to support more precise resource allocation. The study therefore uses the highest score among the three criterion dimensions as an initial assignment heuristic for identifying the primary pathway, without introducing extra thresholds or an additional model. When two dimensions are close, the result is better read as a dominant implementation orientation than as a fixed typology, and later implementation may combine hybrid follow-up actions.

5 Results

5.1 Overall Spatial Distribution

As shown in Fig. 2, the spatial distribution of heritage sites, together with the kernel-density analysis, shows that Lingnan architectural heritage in Qingcheng is characterized by a pattern that is core-clustered yet overall dispersed. High-value zones are concentrated in the old urban core and the riverside area, indicating that commemorative spaces, parks, and commercial streets there strongly overlap with urban activity flows and therefore possess a solid basis for living use. Secondary patches are distributed in areas with relatively good transport connections, whereas many clan and religious heritage nodes appear as scattered points with weaker spatial clustering.

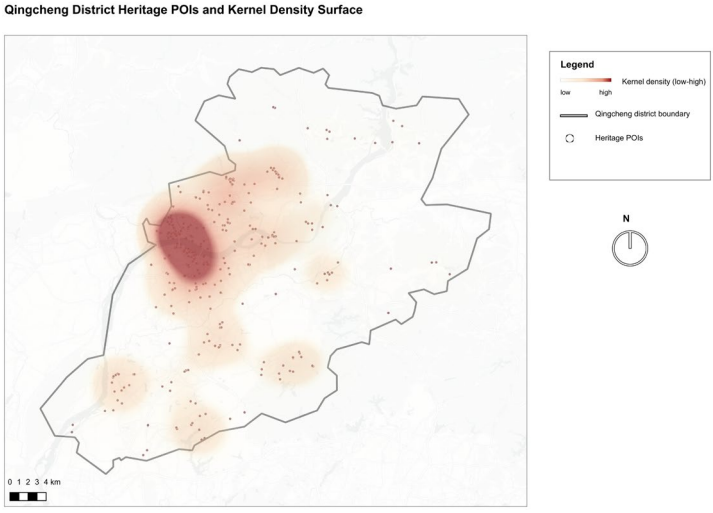

Fig. 2. Spatial distribution and kernel density of heritage-related sites.

This spatial pattern indicates that Qingcheng does not contain a continuous heritage quarter that can be digitized all at once. Instead, it is a mixed heritage field composed of locations with different degrees of connectivity and different social interfaces. A phased deployment strategy based on priority sequence is therefore more consistent with local governance realities and resource constraints than a full-coverage rollout and is better suited to improving both the efficiency and the quality of heritage digital-twin activation.

5.2 Case Ranking Results

Table 3 retains the distinction among archival value, activation potential, and twin-scenario carrying capacity rather than collapsing all heritage attributes into a single score. This preserves the comprehensiveness and objectivity of the evaluation.

The priority ranking shows that Zhongshan Park, the Qingyuan County Revolutionary Martyrs Monument, and Qingyuan Tourism, Culture, and Shopping Street occupy the top three positions, with relative closeness values of 0.7332, 0.7254, and 0.6489, respectively. Notably, the gap between the first two cases is only 0.0078. This indicates that while the leading cases are clearly distinguishable in rank, their advantage is better understood as a relative composite advantage rather than an absolute hierarchical distance, which is consistent with the objective characteristics of multi-criteria evaluation.

When the raw indicator matrix is read together with the priority ranking, it becomes clear that the leading cases do not belong to a single heritage type. Zhongshan Park and Qingyuan Tourism, Culture, and Shopping Street show balanced performance in spatial accessibility, public narrative, and scenario fit and therefore enjoy strong overall advantages. The Qingyuan County Revolutionary Martyrs Monument, by contrast, stands out in archival value while showing no major weakness in activation potential or scenario carrying capacity, which helps keep it near the top of the ranking. By contrast, some religious and commemorative sites perform strongly in a single dimension but rank lower overall because of constraints in surrounding support conditions or scenario-carrying ability. This suggests that TOPSIS does not simply judge which heritage objects are culturally more important; it identifies which ones are better suited to inclusion in first-round deployment and thus preserves the practical orientation of the study.

Table 3. Raw indicator matrix for the 15 representative cases.

No.	Case	Category	C1.1	C1.2	C1.3	C2.1	C2.2	C2.3	C2.4	C3.1	C3.2
1	Zhongshan Park	Landscape heritage	4	3	2	5	5	5	5	5	4
2	Feilai Lake Park	Landscape heritage	2	2	1	4	3	2	3	5	5
3	Xiang Xiuli Community Sports Park	Landscape heritage	2	2	1	5	3	3	4	4	5
4	Rule of Law Park	Landscape heritage	2	2	1	5	3	3	4	5	5

No.	Case	Category	C1.1	C1.2	C1.3	C2.1	C2.2	C2.3	C2.4	C3.1	C3.2
5	Huabin Street	Characteristic commerce	3	3	2	5	3	4	5	4	3
6	Guangtai Commercial Street	Characteristic commerce	3	3	2	5	3	5	4	4	3
7	Qingyuan Tourism, Culture, and Shopping Street	Characteristic commerce	3	3	2	5	5	3	5	4	4
8	Wendong Revolutionary Base Monument	Historical commemoration	5	3	4	5	1	1	4	3	2
9	Qingyuan County Revolutionary Martyrs Monument	Historical commemoration	5	4	5	5	5	4	4	4	3
10	Gangtou Liu Ancestral Memorial Hall	Historical commemoration	4	5	5	3	1	2	3	2	2
11	Deng Family Memorial Hall	Historical commemoration	4	4	4	3	1	5	3	2	2
12	Zheng Ancestral Hall	Religious belief	4	5	5	4	1	2	3	2	2
13	Yuantan Church	Religious belief	4	4	4	5	3	4	3	2	2
14	Dalong Ancient Temple	Religious belief	4	4	4	3	1	1	2	2	1
15	Sanwang Ancient Temple	Religious belief	4	4	4	3	1	1	3	2	1

Note: For C2.1, walking time t converted at 1.2 m/s is mapped to 5/4/3/2/1 points for t <= 5, 5 < t <= 10, 10 < t <= 15, 15 < t <= 20, and t > 20 min, respectively. For C2.2, the three Natural Breaks classes of low/medium/high are mapped to 1/3/5 points. For C2.3, the buffer-based ratio is mapped from low to high quintiles to 1-5 points. C1.1-C1.3, C2.4, and C3.1-C3.2 are assigned by applying the rubric-based interpretive criteria summarized in Table 2.

Table 4. TOPSIS priority ranking and primary pathway identification.

No.	Case	B1	B2	B3	Relative closeness	Rank	Primary pathway
1	Zhongshan Park	3.20	5.00	4.50	0.7332	1	Digital narrative path
9	Qingyuan County Revolutionary Martyrs Monument	4.60	4.46	3.50	0.7254	2	Digital archive path
7	Qingyuan Tourism, Culture, and Shopping Street	2.80	4.64	4.00	0.6489	3	Digital narrative path
5	Huabin Street	2.80	4.46	3.50	0.5926	4	Digital narrative path
6	Guangtai Commercial Street	2.80	4.27	3.50	0.5643	5	Digital narrative path
4	Rule of Law Park	1.80	3.92	5.00	0.5236	6	Digital governance path
3	Xiang Xiuli Community Sports Park	1.80	3.92	4.50	0.5086	7	Digital governance path
13	Yuantan Church	4.00	3.73	2.00	0.4901	8	Digital archive path

No.	Case	B1	B2	B3	Relative closeness	Rank	Primary pathway
2	Feilai Lake Park	1.80	3.10	5.00	0.4456	9	Digital governance path
8	Wendong Revolutionary Base Monument	4.00	3.19	2.50	0.4436	10	Digital archive path
11	Deng Family Memorial Hall	4.00	2.99	2.00	0.4323	11	Digital archive path
12	Zheng Ancestral Hall	4.60	2.73	2.00	0.4191	12	Digital archive path
10	Gangtou Liu Ancestral Memorial Hall	4.60	2.46	2.00	0.4071	13	Digital archive path
15	Sanwang Ancient Temple	4.00	2.28	1.50	0.3207	14	Digital archive path
14	Dalong Ancient Temple	4.00	1.92	1.50	0.2847	15	Digital archive path

Note: Priority rank is determined by TOPSIS relative closeness. The primary pathway is identified from the relative advantage among B1, B2, and B3, using the largest dimension as the initial assignment heuristic. Rank and pathway are related but not identical: units with similar priority may enter different pathways, while units within the same pathway remain ordered by relative closeness. Where dimensional advantages are close, the pathway result should be treated as a decision reference rather than a final typology.

5.3 Pathway Identification

Pathway identification follows a two-step logic. First, the continuous priority ranking of cases is obtained through TOPSIS relative closeness, thereby clarifying which objects should be advanced first. Second, the relative advantages of B1, B2, and B3 are compared to indicate each case's primary pathway. Figure 3 places the ranking in Table 4 alongside each case's dimensional profile, keeping the analytical chain internally consistent.

The results show that the cases at the front of the priority sequence do not converge on a single implementation pathway. Zhongshan Park ranks first overall, yet its highest score lies in B2 (activation potential), so its primary pathway is digital narrative. The Qingyuan County Revolutionary Martyrs Monument ranks second, but because B1 (archival value) is its strongest dimension, its primary pathway points to digital archive. Rule of Law Park ranks only sixth overall, yet its marked advantage in B3 (twin-scenario carrying capacity) suggests digital governance. This shows that ranking establishes sequence, whereas pathway identification indicates the implementation focus for initial work.

Within the same implementation pathway, cases still exhibit clear priority differences. Under the digital narrative path, the cases are ordered from high to low as Zhongshan Park, Qingyuan Tourism, Culture, and Shopping Street, Huabin Street, and Guangtai Commercial Street. Under the digital archive path, a similarly clear hierarchy runs from the Qingyuan County Revolutionary Martyrs Monument down to Sanwang Ancient Temple and Dalong Ancient Temple. This means that cases assigned to the

same primary pathway do not require identical investment intensity or implementation rhythm; they share a common implementation focus, while boundary cases can still combine hybrid follow-up actions where needed.

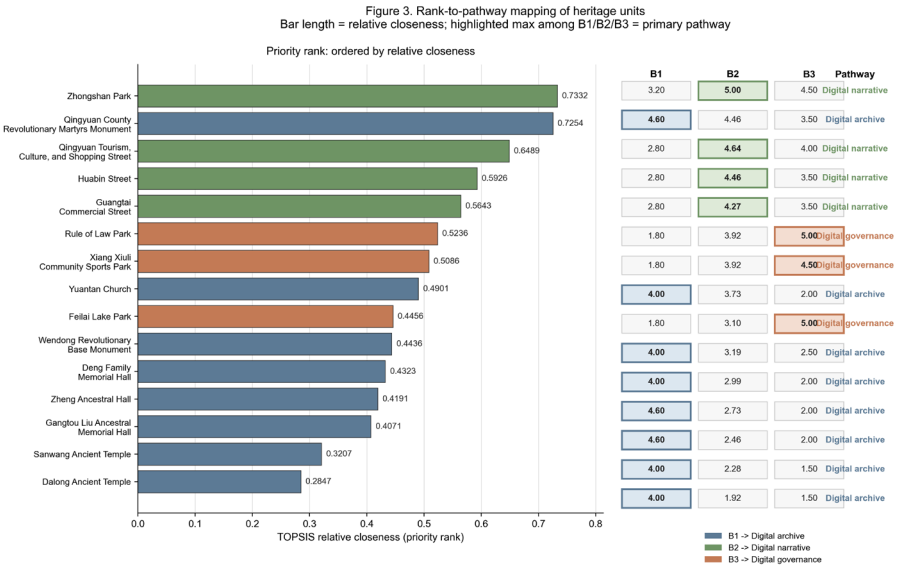

Fig. 3. From priority sequence to primary pathway.

6 Discussion

6.1 From Full-Coverage Twins to Priority-Oriented Implementation

The need for differentiated implementation pathways stems from the fact that different heritage units play markedly different roles in community life across Lingnan. Some units urgently require high-fidelity digitization for archival retention and basic information structuring. Some are better suited to building public-facing interfaces for cultural narrative communication and display. Others are more readily embedded in everyday urban management, event organization, or community-service scenarios. If a uniform digital construction package is applied to all heritage units, two problems are likely to emerge: some units will be over-modeled, wasting scarce resources, while others will receive digital solutions that do not match their actual social functions and therefore fail to generate value.

In the context of living heritage protection and deep community embedding, heritage digital twins should not be defined simply as a unified three-dimensional replica of the physical entity, but as governance tools that can be dynamically adjusted to the social roles of heritage. For small and medium-sized cities, differentiated implementation pathways are not technological spectacle but a scientifically grounded allocation mechanism under resource constraints. The digital archive path centers on archival

structuring and long-term retention of heritage information; the digital narrative path centers on value interpretation, dissemination, and public reach; and the digital governance path centers on building interfaces between heritage and the urban governance system and embedding heritage in everyday scenarios. A pathway-oriented implementation logic matched to heritage characteristics is therefore a necessary precondition for digital-twin activation.

At the practical level, the three primary pathways identified here should be understood as first-phase action logic rather than complete end-state engineering packages. For small and medium-sized cities, the immediate task is to clarify construction focus and resource direction for different types of heritage units, not to complete all chains and modules of digitalization at once. Table 5 therefore summarizes the first-phase objectives, core digital actions, and principal governance implications associated with the three pathways.

Table 5. First-phase action logic for the differentiated pathways.

Primary pathway	First-phase objective	Typical digital actions	Main governance implication
digital archive	Stabilize the integrity of digital archiving for high-value objects first.	Basic surveying, archive organization, condition recording, and document linkage.	Provide a traceable basis for subsequent conservation, renewal, and resource allocation.
digital narrative	Strengthen public reach and interpretation first.	Narrative structuring, route linkage, interpretive interfaces, and lightweight display.	Improve heritage visibility and public activation capacity under limited budgets.
digital governance	Connect heritage nodes to management and service scenarios first.	Basic dashboards, activity coordination, and linkage of environmental and safety information.	Translate heritage activation into everyday coordination and community-service value.

Note: Table 5 presents first-phase action logic and lightweight implementation guidance. It does not constitute a complete engineering package or replace subsequent detailed planning.

6.2 Governance Implications of Priority Objects and Implementation Pathways

In the development context of Lingnan small and medium-sized cities, heritage digital-twin activation is essentially a task of resource optimization and governance prioritization. This logic is highly consistent with the current direction of digital twin city research, which increasingly emphasizes improved governance capacity and more complete institutional systems [2,3]. For Qingcheng, this means that heritage digital twin construction must remain priority-oriented rather than prematurely pursue full-area, full-coverage rollout. Table 5 turns the three primary pathways from abstract conceptual labels into lightweight guidance for budgeting, work organization, and task decomposition. In other words, digital archive, digital narrative, and digital governance are not three closed technical systems; they are differentiated directions for early resource input. Detailed costing, staffing requirements, and pilot testing remain beyond the scope of this conference paper.

The living value and community-embedded value of heritage should be substantively incorporated into priority evaluation rather than remain at the level of theoretical rhetoric. In this study, Zhongshan Park and Qingyuan Tourism, Culture, and Shopping Street rank near the top precisely because their everyday accessibility, surrounding business vitality, and capacity for cultural narrative transmission directly strengthen their evaluative performance. This is highly consistent with work on living heritage conservation and community renewal, which emphasizes the connection between the contemporary use value of heritage and its social functions [8-13].

Priority ranking alone is insufficient for practical decision-making. Relative closeness clarifies which heritage units should enter the construction sequence, while comparison of B1, B2, and B3 indicates where effort should begin: digital archiving, narrative interfaces, or governance linkage. This does not prescribe a full engineering scheme; it offers a practical way to connect sequencing with implementation focus under resource constraints. For small and medium-sized cities in northern Guangdong, combining these two questions within one evaluation system makes resource-allocation decisions clearer and easier to operationalize.

6.3 Boundary Conditions and Limitations

As an evaluative study, this paper operates within a fixed case set, indicator system, and AHP weight structure and does not attempt causal identification of performance changes in heritage conservation, tourism development, or urban governance after digital twin intervention. The relative closeness values express deployment priority within this framework rather than absolute heritage value, and the pathway result should likewise be read as a practical indication of implementation focus rather than a final typology. Because the ranking is framework-dependent and sensitive to the adopted weights, subjective scoring rules, and GIS-based spatial data, it should not be copied directly to other cities. What transfers is the underlying decision logic, while future studies may compare plausible alternative weight configurations and recalibrate scoring rules for different local contexts.

7 Conclusion

Focusing on Qingyuan as a Lingnan small and medium-sized city characterized by spatially dispersed heritage and limited construction resources, this paper addresses a central practical question: in what sequence should heritage digital-twin activation proceed, and from which direction should it begin? To answer this question, the study constructs an integrated analytical framework that combines GIS spatial analysis, AHP weighting, and TOPSIS ranking, bringing spatial evidence extraction, indicator weighting, and case prioritization into a unified decision process.

The 15 representative cases display a clear but not rigid hierarchy of priority. Zhongshan Park, the Qingyuan County Revolutionary Martyrs Monument, and Qingyuan Tourism, Culture, and Shopping Street rank highest, suggesting that initial attention can reasonably focus on heritage units that combine spatial accessibility, narrative

extensibility, and strong multi-scenario carrying capacity under the adopted framework. At the same time, the relative closeness gap between the top two cases is very small, which suggests that the ranking captures relative deployment priority rather than a final judgment on intrinsic heritage value.

On the basis of the ranking, the paper further links sequence to pathway and thus translates the results into three practical directions: digital archive, digital narrative, and digital governance. For Qingcheng and similar small and medium-sized cities in northern Guangdong, the value of this approach lies in showing not only which heritage units should move first, but also where early implementation should concentrate. This remains a staged decision reference rather than a final typology under the adopted framework, not a ready-made template to be transferred unchanged to other cities. What small and medium-sized cities need is therefore not simultaneous full-area, high-investment rollout, but a defensible starting sequence and an equally clear implementation focus.

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