ACCSCIENCE PUBLISHING

Journal of Chinese Architecture and Urbanism

ORIGINAL ARTICLE

Prioritizing adaptive reuse of industrial heritage in Nanchang, China: An analytic hierarchy process-based approach

Songqi Gui and Mohd Jaki Bin Mamat*

School of Housing, Building & Planning, Universiti Sains Malaysia, Penang, Malaysia

Abstract

Amid the uneven and fragmented regeneration of industrial heritage in Nanchang, China, decision-makers face challenges in prioritizing former industrial sites for adaptive reuse. These challenges arise from competing heritage, social, economic, and environmental objectives. To address this, an explicitly specified analytic hierarchy process-based framework is proposed. The decision structure is organized around seven criteria: historical value (HV), cultural value (CV), economic benefits (EE), development potential, accessibility (AC), social impact (SI), and ecological sustainability (ES). Expert pairwise comparisons are rigorously verified through consistency index and ratio (CI/CR) checks. These expert judgements are integrated with public preferences using a 70:30 weighting between experts and the public. The top three public rankings are converted into quantitative weights using the rank-reciprocal rule. Three candidate sites, Jiangfang 1953, Nanchang 699, and Zhangshulin, were evaluated using this framework. Jiangfang 1953 emerged as the top-ranked site, primarily driven by HV, CV, and SI, and further supported by strong ES performance. Nanchang 699 ranks second, largely due to its advantages in AC and EE. Zhangshulin excels in ES but demonstrates lower readiness for implementation. The robustness of these results is confirmed through CI/CR screening, one-at-a-time weight-sensitivity analyses (±5% and ±10%, with no rank reversals), and diagnostic comparisons between expert and public preferences. The framework clarifies trade-offs, validates weighting assumptions, and facilitates staged interventions and effective stakeholder communication. Beyond this case study, the approach is adaptable to any context where professional judgment and community preferences must be combined under explicitly defined, testable assumptions.

Keywords: Delphi method; Stakeholder preference fusion; Explicitly specified decision-making; Sensitivity analysis; Geographic information system corroboration; Industrial heritage; Adaptive reuse

***Corresponding author:**
Mohd Jaki Bin Mamat
(mohdjaki@usm.my)

Citation: Gui, S. & Bin Mamat, M. J. (2026). Prioritizing adaptive reuse of industrial heritage in Nanchang, China: An analytic hierarchy process-based approach. *Journal of Chinese Architecture and Urbanism*. 8(4):025500096. https://doi.org/10.36922/JCAU025500096

Received: December 10, 2025

Revised: February 12, 2026

Accepted: February 12, 2026

Published online: April 22, 2026

Copyright: © 2026 Author(s). This is an Open-Access article distributed under the terms of the Creative Commons AttributionNon-Commercial 4.0 International (CC BY-NC 4.0), which permits all non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Publisher's Note: AccScience Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Adaptive reuse of industrial heritage has become a central strategy in urban renewal, delivering benefits across cultural, social, economic, and environmental aspects (J. Chen *et al.*, 2016; Nocca, 2017; Vafaie *et al.*, 2023). Flagship cases such as the Zollverein Coal Mine in Germany and Beijing's 798 Art District demonstrate how adaptive reuse preserves historical fabric and narratives, strengthens place identity, and supports

sustainability (Mieg & Oevermann, 2014; Vafaie *et al.*, 2023). In Nanchang, a diverse industrial legacy in machinery, textiles, and aviation (Duan *et al.*, 2020), partly shaped by the Xiao Sanxian program (Ge & Dai, 2018), has left behind Soviet-style plants, workshops, and factory–housing compounds (Nanchang Municipal Bureau of Natural Resources, 2020a, 2020b; Nanchang Municipal People's Government, 2024). However, outcomes have been uneven. For example, Hongdu demonstrates social gains but experiences slow upgrades due to financing and policy constraints. Nanchang 699 Creative Park (699) has improved the urban environment but still requires enhancements in transportation infrastructure and public space optimization (He *et al.*, 2017; Xie, 2022).

Methodologically, the analytic hierarchy process (AHP) is widely applied in heritage and urban-renewal decision-making. Its application has expanded in recent years to the evaluation of adaptive reuse of industrial heritage and buildings. Several recent studies have employed AHP, including its fuzzy and extended variants, to assess the reuse potential of former industrial facilities and to inform redevelopment strategies within industrial heritage contexts (Bottero *et al.*, 2019; Claver *et al.*, 2020; Lian & Dimitrijević, 2025; Milošević *et al.*, 2020; Nadkarni & Puthuvayi, 2020). Yet, numerous assessments focus narrowly on limited dimensions, vary in the selection of indicators and weighting schemes, and insufficiently integrate expert judgment with public preferences (Bottero *et al.*, 2019; Cucco *et al.*, 2023; Langston *et al.*, 2008; Nadkarni & Puthuvayi, 2020). In Nanchang, standards for adaptive reuse remain fragmented, and the underlying data infrastructure is weak.

Despite the widespread application of AHP and related multi-criteria approaches in heritage and industrial redevelopment studies, existing research reveals three key limitations. First, indicator systems are often inconsistent across studies. Second, public preferences are rarely integrated systematically into weighting procedures. Third, the robustness of prioritization results is insufficiently tested. In Nanchang, where industrial heritage regeneration remains fragmented and uneven, these gaps hinder the establishment of an explicit, reliable basis for determining which sites should be prioritized for adaptive reuse.

Although AHP has proven effective in complex heritage settings (Bottero *et al.*, 2019), systematic reviews and methodological comparisons reveal persistent fragmentation in criteria and weighting schemes (Nadkarni & Puthuvayi, 2020; Nesticò & Somma, 2019). In particular, there is limited evidence on the trade-offs and interrelationships among key dimensions, such as historical value (HV), economic benefits (EE), and development potential (DP). There is also a lack of operational procedures that effectively translate these criteria into practical site-selection tools (Vafaie *et al.*, 2023; Yang *et al.*, 2021). To address these gaps, a comprehensive AHP-based multi-criteria decision-making (MCDM) framework is developed. The framework quantifies and prioritizes HV, cultural value (CV), EE, DP, accessibility (AC), social impact (SI), and ecological sustainability (ES), providing a reusable and auditable basis for site selection in Nanchang.

This study aims to develop and apply a well-defined, context-specific MCDM framework for prioritizing the adaptive reuse of industrial heritage sites in Nanchang, China. By integrating expert judgment with public preferences under explicit consistency control, the study provides a reproducible and operational basis for decision-making. It aims to identify which industrial heritage sites should be prioritized while balancing competing heritage, social, economic, and environmental objectives. The research objectives are threefold:

- To identify key indicators relevant to Nanchang.
- To develop an AHP-based MCDM model and quantify the weights of each criterion.
- To evaluate candidate sites and propose sustainable intervention strategies.

The corresponding research questions are as follows:

- How can relevant indicators be defined and screened effectively?
- How can an AHP model be constructed with quantified weights while ensuring logical coherence through consistency checks using the consistency index (CI) and consistency ratio (CR)? Can candidate sites be prioritized to provide actionable guidance for decision-makers?

The contributions of this study are threefold: (i) It introduces a systematic AHP–MCDM framework that integrates seven criteria: HV, CV, EE, DP, AC, SI, and ES; (ii) It delivers an operational tool that generates prioritized results, supporting project delivery and informing policy trade-offs in Nanchang; (iii) It establishes an auditable evidence trail by combining expert judgment with consistency checks and one-at-a-time (OAT) sensitivity analysis, thereby enhancing methodological rigor and transparency.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature on industrial heritage reuse and MCDM. Section 3 introduces the evaluation framework, data collection, and the AHP-based methodology. Section 4 presents the prioritization results and robustness analysis. Section 5 discusses the findings and their implications for industrial heritage regeneration, and Section 6 provides the conclusion of this study.

2. Literature review

2.1. Studies on the analytic hierarchy process in related fields

Within adaptive-reuse research, four primary strands dominate: (i) applications of decision-analytic tools; (ii) evaluation of HV and CV; (iii) analyses of EE and DP; and (iv) case-driven syntheses of successful projects. The AHP, a MCDM method, hierarchically structures complex problems. It derives criterion weights from pairwise comparisons and incorporates explicit consistency checks (Belton & Stewart, 2002; Claver *et al.*, 2020; Cucco *et al.*, 2023; Saaty, 1980). In adaptive-reuse contexts, AHP has been widely applied to balance cultural, economic, social, and environmental objectives and to prioritize alternative interventions. HV and CV frequently occupy central roles in these evaluations (Lian & Dimitrijević, 2025; Meng *et al.*, 2023; Yang *et al.*, 2021). Overall, community participation is consistently highlighted as a critical factor for successful outcomes (Gallou & Fouseki, 2019). Meanwhile, EE and DP remain strongly associated with implementation success (De Gregorio *et al.*, 2020).

2.2. Principles for the analytic hierarchy process model development and indicator selection

The development of the AHP model is guided by three core principles: scientific rigor, comprehensiveness, and context specificity. Scientific rigor is ensured through hierarchical decomposition, pairwise comparisons, and consistency testing, providing reliable measurements and auditability (Belton & Stewart, 2002; Forman & Peniwati, 1998; Saaty, 1980). Comprehensiveness requires the inclusion of HV, CV, EE, DP, AC, SI, and ES, reflecting the multi-dimensional objectives of adaptive reuse projects (De Gregorio *et al.*, 2020; Ferretti *et al.*, 2014; Nesticò & Somma, 2019; Nocca, 2017; X. Chen *et al.*, 2024). Additionally, context specificity aligns indicators and weights with local conditions, using Delphi-guided expert input and field validation to ensure relevance and applicability (Bottero *et al.*, 2019; Bouaziz & Guechi, 2024; Lian & Dimitrijević, 2025; Nadkarni & Puthuvayi, 2020; Yang *et al.*, 2021).

2.2.1. Overarching theoretical framework

The AHP decomposes complex problems into hierarchical structures. It elicits pairwise judgments on a ratio scale and derives priorities using eigenvector methods. Internal coherence is assessed through the CI and CR (Saaty, 1980). To address uncertainty in judgments, fuzzy AHP variants—such as Buckley's triangular-fuzzy method and Mikhailov's α-cut procedure—extract robust priorities from imprecise comparisons. In comprehensive evaluations, AHP-derived weights are often integrated with distance- or outranking-based ranking methods, including Technique for Order Preference by Similarity to Ideal Solution and Elimination and Choice Expressing Reality. Project-oriented frameworks, in contrast, adapt AHP to architectural and industrial heritage renewal (Hwang & Yoon, 1981; Roy, 1991).

2.2.2. Comparative overview of typical analytic hierarchy process models in industrial heritage

To illustrate alternative AHP pathways, four representative model types are compared based on research objectives, hierarchy depth, and criteria design (Table 1). The overview

Table 1. Typical AHP models in industrial heritage

Model type	Representative reference	Research objective	Hierarchy depth	Main criteria categories
Traditional AHP for value assessment	Lian and Dimitrijević (2025), AHP-based evaluation/reuse of a steel plant (Shaanxi)	Estimate multi-dimensional value weights and compute aggregate scores	3: goal–criteria–subcriteria/options	Historical; artistic/cultural; technological; environmental; social; economic
Matrix AHP for industrial heritage	X. Chen *et al.* (2024), "Industrial Heritage Matrix–AHP," Mawei Shipbuilding (Fuzhou)	Build an 8-dimensional value matrix; partial & overall evaluation	3: goal–8 criteria–options	Historical; artistic; social; cultural; technological; economic; environmental; functional
GIS–AHP for siting/potential assessment	Bouaziz and Guechi (2024), El Hamma Industrial Zone, Algiers	Weight spatial factors to map suitability/potential zones	2–3: goal–criteria(–subcriteria)	Environmental risk; infrastructure; accessibility; conservation; economic potential
AHP with Dempster–Shafer (DS) evidence fusion	Liu, Zhao, and Yang (2018), AHP + DS for 16 sites	Fuse evidence and classify conservation levels under uncertainty	3: goal–criteria–options	Historical; artistic/technological; socio-economic; surrounding environment

Abbreviations: AHP: Analytic hierarchy process; GIS: Geographic information system

guides subsequent decisions on indicator selection and model scope for the present study.

2.2.3. Differentiated positioning of the present study

The study aligns its criterion system with site selection by extending beyond conventional dimensions of history, culture, economy, and environment. ES is treated as a distinct criterion, while AC, DP, and SI are explicitly specified to account for siting constraints. Consensus on criteria is established using the Delphi method, in which experts provide detailed 1–9 pairwise comparisons and public respondents contribute simplified rankings or star ratings, which are subsequently mapped to AHP weights. Additionally, spatial indicators are employed to corroborate AC but do not replace the three-level AHP structure, which maintains CI/CR control for reliability and auditability (Supplementary C3; Geographic information system [GIS] corroboration in Supplementary E1). The study focuses on three candidate sites in Nanchang for concrete site selection, rather than broader park-level classification, ensuring a targeted and context-specific application.

3. Methodology

An AHP-based MCDM framework was developed in this work to prioritize adaptive-reuse sites in Nanchang. As illustrated in Figure 1, the workflow comprised four key steps:

(i) Screening of evaluation criteria
(ii) Questionnaire design and data collection
(iii) Weight estimation and ranking of alternatives
(iv) Robustness and heterogeneity checks

Detailed instruments, the random index (RI) list, templates, code, and quality-control logs are provided in Supplementary A–E.

3.1. Screening and confirmation of evaluation criteria

The AHP-based criteria system was developed through three sequential steps. First, a systematic literature review was conducted to construct an initial indicator pool. Second, two Delphi rounds were used to converge on the first-tier criteria. Third, the indicators were operationalized in

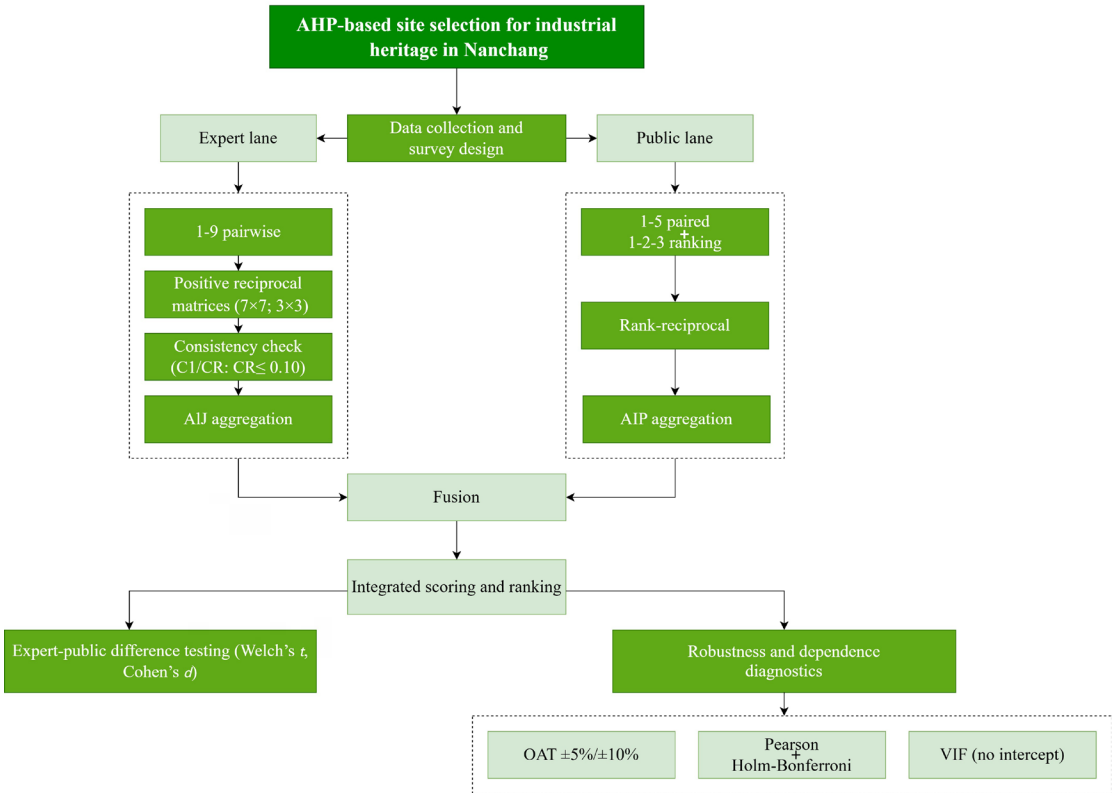


Figure 1. Data-analysis workflow
Abbreviations: AHP: Analytic hierarchy process; AIJ: Aggregation of individual judgments; AIP: Aggregation of individual priorities; CI: Consistency index; CR: Consistency ratio; OAT: One-at-a-time; VIF: Variance inflation factor. Source: Diagram by the authors

alignment with international standards and local fieldwork. Search and eligibility are presented in Supplementary A, while the literature–indicator 1–0 matrix and frequency analysis are included in Supplementary B. Delphi instruments and summaries are documented in Figures S1 and S2 and Tables S7 and S8. Using Web of Science (Science Citation Index/Social Science Citation Index), studies published between 2019 and 2025 on industrial heritage and brownfield adaptive reuse that incorporate AHP or MCDM methods are retrieved. The International Council on Monuments and Sites (ICOMOS) and the International Committee for the Conservation of the Industrial Heritage (TICCIH) guidelines informed value orientation and terminology. After screening, 12 peer-reviewed articles were retained. Synonyms were merged to create a 14-item pool (Table 2; full list in Table S3). This pool was refined for local relevance in Delphi Round 1. The literature–indicator matrix yielded seven first-tier criteria: HV, CV, EE, DP, AC, SI, and ES. These criteria align with recent MCDM frameworks and TICCIH/ICOMOS guidance on intrinsic value, integrity, and sustainable reuse.

Table 2. Original indicators and representative basis

No.	Indicator name (initial pool)
1	Historical and cultural value
2	Physical condition and structural integrity
3	Economic feasibility and value
4	Social impact and community participation
5	Environmental impact and sustainability
6	Spatial fit and functional compatibility
7	Location and accessibility
8	Policy, regulation, and governance
9	Innovation and mixed functions
10	Health and risk, ecological remediation
11	Local identity and cultural affiliation
12	Market demand and use prospects
13	Industrial type and development potential
14	Residual heritage and site attributes

Note: "Local identity and cultural affiliation" in the initial pool was merged into cultural value during convergence. Location-related measures were operationalized under accessibility

3.1.1. Two-round Delphi expert consultation

Two Delphi rounds were conducted to finalize the evaluation criteria. Nine experts (n = 9) from six sectors, each with at least 10 years of experience, were recruited (Supplementary B1, Table S6). In round 1, the 14 indicators were rated using a five-point Likert scale. The top ten indicators were retained based on mean scores and further screened using standard deviation, coefficient of variation, interquartile range, and a content validity index of 0.78 or higher (Supplementary B4, Table S7). Round 2 provided feedback confirmation, resulting in the selection of seven first-tier criteria: HV, CV, EE, DP, AC, SI, and ES. It is worth noting that the Delphi–AHP combination is widely recognized and well established in heritage and built-environment research (Lian & Dimitrijević, 2025). The Delphi instruments are provided in Supplementary B2 and B3, and the full "14 → 10 → 7" convergence process is documented in Supplementary B4.

3.1.2. Core criteria: Definitions and operationalization

Guided by TICCIH and ICOMOS standards and informed by local fieldwork, operational definitions and measurement items were developed for the seven criteria. This ensures both scientific soundness and local relevance for the AHP model. Table 3 summarizes the definitions, key measures, data sources, and 1–5 rating anchors for each criterion. For AC, option performance is measured with objective AC indicators and subsequently mapped to local AHP weights (Section 3.2.2).

3.2. Questionnaire design and survey instruments

In this study, an AHP-based framework was developed to evaluate HV, CV, EE, DP, AC, SI, and ES. These dimensions were treated as conceptually independent while remaining interdependent in decision-making. The AC dimension was validated using objective indicators and then mapped to localized AHP weighting. It was emphasized that GIS data and maps functioned solely as external supporting evidence. The implementation of the framework was guided by two reference tables. Table 4 outlines the criteria, operational definitions, and key references. Table 5 provides a qualitative benchmarking of the three candidate sites.

3.2.1. Expert survey instrument

Standard AHP procedures were applied to the seven criteria finalized through the Delphi process (blank template in Supplementary C1):

(i) Structure: Experts completed a 7 × 7 pairwise criteria matrix using the Saaty 1–9 scale (Saaty, 1980). For each criterion, they also completed a 3 × 3 alternative matrix comparing the three candidate sites: 699, Zhangshulin Cultural Life Park (ZSL), and Jiangfang 1953 (JF 1953) (Table 6).

(ii) Consistency: For each matrix, the CI and CR were computed as follows (**Equations 1 and 2**):

$$\mathrm{CI} = \frac{\lambda_{\max} - \mathrm{n}}{\mathrm{n} - 1} \quad (1)$$

Table 3. Operational definitions and measurement focus for the seven 1st-tier criteria

Abbreviation	Operational definition	Key measures	Data sources and quantification	Rating anchors (1–5)
HV	Authenticity, integrity, rarity	Period/lineage; protection level; fabric/structure/workmanship integrity; rarity/representativeness	Literature/archives/measured drawings; integrity checks; weighted by listing level	1 = low integrity + not listed; 5 = high integrity + national/ provincial protection
CV	Local memory and identity expression	Oral histories/story-point density; retention of memory elements; community recognition (Likert); capacity for cultural programming	Resident/worker surveys and interviews; element checklist; annual cultural events	1 = weak recognition, key elements missing; 5 = strong recognition, elements intact
AC	Connectivity to the urban network	Distances to metro/bus/arterials; network-based accessibility; walk/ bike catchments; links to heritage corridors/landscape belts	GIS distance/network analysis; 30/15/10-min isochrones; MCR overlays	1 = poor transit, fractured links; 5 = multimodal high access + corridor node
DP	Structural, spatial, and site fit	Safety grade; floor height/span/grid; reversibility/flexibility; site size/clear height; compliance	Structural re-check; BIM geometry audit; reversibility checklist; land-use/ compliance list	1 = weak structure + constrained space; 5 = sound structure + high flexibility + compliant
SI	Contribution to public well-being	Employment/training; cultural and public-service supply; accessibility equity gains; participatory governance (actors/depth)	Project estimates and O&M data; baseline vs. post indicators; participation records	1 = weak/uneven gains; 5 = significant gains + high participation
EE	Cost–benefit and market match	Demand (targets, absorption, rent/ sales); CAPEX/OPEX, IRR/NPV/ payback; industrial synergy	Market survey; financial models; supply-chain match scoring	1 = weak demand + financially infeasible; 5 = strong demand + financially robust
ES	Carbon, energy, and ecological health	Operational energy and saving potential; embodied-carbon retention; sponge/stormwater and green–blue integration; remediation compliance; health risks	Energy baselines/saving estimates; LCA screening; sponge-facility ratio; third-party EIA/soil tests	1 = high energy use/risks; 5 = low energy + remediation in place

Abbreviations: AC: Accessibility; BIM: Building information modeling; CAPEX: Capital expenditure; CV: Cultural value; DP: Development potential; EE: Economic benefit; EIA: Environmental impact assessment; ES: Ecological sustainability; GIS: Geographic information system; HV: Historical value; IRR: Internal rate of return; LCA: Life cycle assessment; MCR: Maximum continuous rating; NPV: Net present value; O&M: Operation and maintenance; OPEX: Operating expenditure; SI: Social impact

Table 4. Analytic hierarchy process evaluation criteria and operational definitions

Criterion	Operational definition/measurement focus	Key references
HV	Authenticity and integrity; sense of age; rarity/completeness of historical remains	Li *et al.* (2023); Lian and Dimitrijević (2025); Mieg and Oevermann (2014)
CV	Local identity and community memory; clarity/completeness of narrative; educational potential	Gallou and Fouseki (2019); J. Chen *et al.* (2016); Mieg and Oevermann (2014)
EE	Direct revenue/cash flow; employment and economic spillovers; land/ rent value uplift	Jones and Munday (2001); Langston *et al.* (2008); Shipley *et al.* (2006)
DP	Structural layout/floor height; regulatory and technical feasibility; market viability	Langston et al. (2008); Yung and Chan (2011)
AC	Proximity to rail/bus (distance/time), stop density/coverage, 10-min walksheds; GIS-based mapping with local weighting	La Rosa (2013); Supplementary E1 (methods/data)
SI	Community cohesion; participation in public events; inclusion and well-being	Gallou and Fouseki (2019); Nocca (2017)
ES	LCA-based carbon footprint; energy savings/renewable use; stormwater management/greening	De Gregorio *et al.* (2020); Nocca (2017)

Abbreviations: AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; GIS: Geographic information system; HV: Historical value; LCA: Life cycle assessment; SI: Social impact

Table 5. Qualitative benchmarking of three candidate sites across seven criteria

Criterion	Nanchang 699 Creative Park	Zhangshulin Cultural Life Park	Jiangfang 1953
HV	Retained boiler-house walls and some workshops; visible iconography; moderate integrity	~40% of 1960s cotton warehouses and timber workshops retained	Main weaving plant, old looms, red-brick facades retained; highest integrity
CV	>160 creative tenants; regular exhibitions; strong branding	Family lawn and warehouse market; leisure-oriented	Textile history displays and workshop teaching; the most complete narrative
EE	Higher rents and visitor spending; strong cash flow	Leisure F&B; weekend-driven; moderate returns	Education/training and maker spaces; longer payback, high value-add potential
DP	Reinforced concrete frame; ~6 m floor height; flexible retrofit options	Open landscaping/light structures; limited potential for deep retrofit	Steel + brick structure; large spans; ~8 m floor height; high flexibility for redevelopment
AC	Metro L2 Xinjia'an ~800 m; 4 bus lines; ~300 parking spaces	Metro L4 Qifeng Rd ~100 m; 3 bus lines; ~120 parking spaces	Metro L4 Minyuan Rd West ~900 m; 3 bus lines; ~260 parking spaces
SI	~60 creative markets per year; active young user base	Family camping and night runs; strong interaction	Community textile museum and volunteer tours; high education/participation
ES	Partial PV installation and LEDs; limited greenery	Native camphors and rain gardens; strong carbon-reduction impact	~300 kW PV; soil remediation; moderate greenery and energy savings

Abbreviations: AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; F&B: Food and beverage; HV: Historical value; LED: Light-emitting diode; PV: Photovoltaic; SI: Social impact

$$CR = \frac{CI}{RI} \quad (2)$$

A CR ≤ 0.10 was required for acceptance (Supplementary C3; Table 7).

(iii) Aggregation: Group matrices were aggregated using the geometric mean (**Equation 3**):

$$A_{ij}^{E} = \left(\prod_{k=1}^{m} A_{ij}^{(k)}\right)^{1/m} \quad (3)$$

(iv) Priority vectors, when applicable, adopted the aggregation of individual priorities (AIP) (**Equation 4**):

$$w^{P} = \frac{1}{m}\sum_{K=1}^{m} w^{(K)} \quad (4)$$

(v) Sample and quality control: Nine experts with ≥10 years of experience were recruited from universities, research institutes, government/subdistrict offices, design firms, enterprises, and park operations (Supplementary B1). Only matrices with CR ≤ 0.10 were retained. Pass rates are summarized in Table 8.

3.2.2. Public survey instrument

A simplified survey instrument was designed to preserve AHP computability while minimizing respondent burden (Forman & Peniwati, 1998; Saaty, 1980). Public preferences were subsequently fused with expert judgments at a 30:70 ratio (public:expert) using AIP/aggregation of individual judgments (AIJ) (Supplementary C3 and C6):

(i) Structure: At the criteria level, respondents provided 1–5 pairwise judgments mapped to the AHP subset. At the alternative level, respondents gave strict 1–2–3 rankings for each criterion.

(ii) Criteria mapping: Pairwise ratings from 1–5 were mapped directly to the scale {1,2,3,4,5}, and reciprocals were applied to form a 7 × 7 matrix with diagonal entries a_{ii} = 1. A CR ≤ 0.10, RI = 1.36, and n = 7 were required for acceptance at the criteria level.

(iii) Rank-to-weight conversion: Alternative-level ranks (1–2–3) were converted to weights using the rank–reciprocal formula (**Equation 5**):

$$w_{(r_i)} = \frac{1/r_i}{\sum_{k=1}^{m} 1/k} \quad (5)$$

For m = 3, this yields weights of (6/11, 3/11, 2/11) ≈ (0.545, 0.273, 0.182).

(iv) Aggregation and fusion: Public criteria weights were aggregated using AIP (**Equation 4**). Global weights were then computed as in **Equation 6**:

$$W = \alpha WE + (1-\alpha)WP, \alpha = 0.70 \quad (6)$$

(iv) Sample and quality control. Twelve valid public responses were collected via on-site surveys and WeChat H5 mini-programs (Supplementary C2). A stratified subsample of 6 respondents provided alternative-level 1–2–3 rankings. CR ≤ 0.10 was

Table 6. Structure of the expert questionnaire and item counts

Level	Objects of judgment	Matrix size	Entries to complete	Consistency threshold
Criteria	Seven first-tier criteria (HV, CV, AC, DP, SI, EE, ES)	7 × 7	C(7,2) = 21	CR ≤ 0.10 (n = 7, RI = 1.36)
Alternative	Three sites per criterion (699, ZSL, JF 1953)	3 × 3 × 7 criteria	C(3,2) = 3 each; total 21	CR ≤ 0.10 (n = 3, RI = 0.52)

Notes: Saaty 1–9 scale; only upper-triangle entries counted; all matrices positive-reciprocal. RI values are presented in Supplementary C3.
Abbreviations: AC: Accessibility; CR: Consistency ratio; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; JF 1953: Jiangfang 1953; RI: Random index; SI: Social impact; ZSL: Zhangshulin Cultural Life Park

Table 7. Analytic hierarchy process consistency thresholds and handling rules

Matrix order, n	RI	Decision formula	Acceptance	Handling rule
7	1.36	CR = CI/RI	CR ≤ 0.10	If CR > 0.10 → one-time review; if still >0.10, exclude
3	0.52	CR = CI/RI	CR ≤ 0.10	If CR > 0.10 → one-time review; if still >0.10, exclude
1–2	0.00	NA	NA	Trivially consistent; no test

Abbreviations: CI: Consistency index; CR: Consistency ratio; NA: Not available; RI: Random index

Table 8. Sample and returns

Sample type	Distributed	Returned	Passed (CR ≤ 0.10)	Pass rate	Remarks
Experts	9	9	9	100%	One matrix passed after a single re-check
Public	12	12	12	100%	Four residents, three merchants, two managers, three visitors; all used for weight statistics

Abbreviation: CR: Consistency ratio

achieved for the 7 × 7 criteria matrices (RI = 1.36). Alternative-level public inputs used the rank–reciprocal method, for which CR testing was not applicable.

3.3. Sample collection and data quality control

3.3.1. Site-selection evaluation framework for industrial heritage in Nanchang

This study adopts a three-level hierarchical framework comprising the goal, criteria, and alternatives. The primary goal is to identify the most suitable site for adaptive reuse within Nanchang's industrial heritage. Seven evaluation criteria were employed: HV, CV, EE, DP, AC, SI, and ES. The alternatives consisted of three candidate sites: 699, ZSL, and JF 1953. Relative weights for each criterion were derived from pairwise comparisons, with consistency validated via CI/CR testing (Saaty, 1980). These weights enabled the calculation of composite rankings, allowing for direct comparison among the candidate sites. Conceptually, HV and CV underpinned heritage conservation and narrative integrity. EE and DP reflected the practical feasibility and implementability of adaptive reuse interventions. AC and SI captured factors influencing project AC, public engagement, and SI. Finally, ES represented environmental performance and long-term sustainability of the redevelopment (Table 9). Figure 2 illustrates the hierarchical structure of the site-selection framework, and Figure 3 presents the locations and on-site photographs of the three case study sites.

4. Results

The findings of this study are reported across five dimensions: (i) criterion weights, (ii) alternative-level weights, (iii) composite rankings, (iv) robustness analyses, and (v) group differences. Consistency of the pairwise comparisons was assessed using **Equations 1 and 2**. The analysis includes evaluations from both experts and the public, as well as an integrated weighting scheme that combines these perspectives. Conditional weights, overall composite scores, and final rankings are synthesized to illustrate the relative performance of the candidate sites. To assess the stability and reliability of the results, OAT sensitivity analyses were conducted with ±5 percent and ±10 percent variations in criterion weights. Comparisons between expert and public evaluations, including mean differences and effect sizes, were performed to examine the

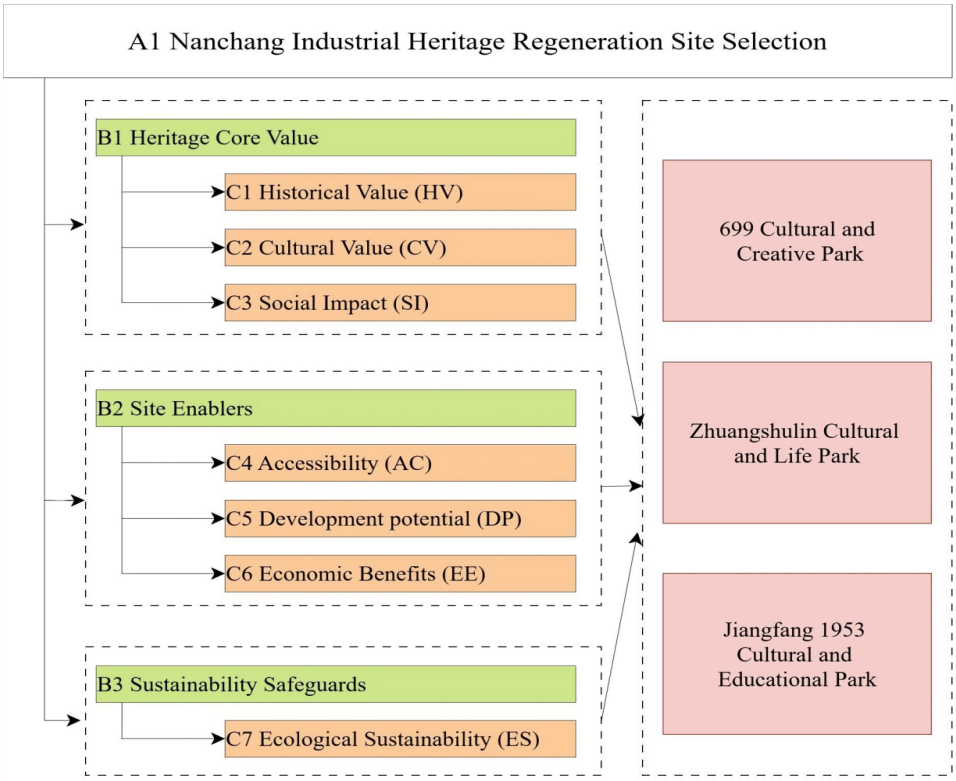


Figure 2. Hierarchical analytic hierarchy process-based framework for site selection in adaptive reuse projects in Nanchang. Source: Diagram by the authors

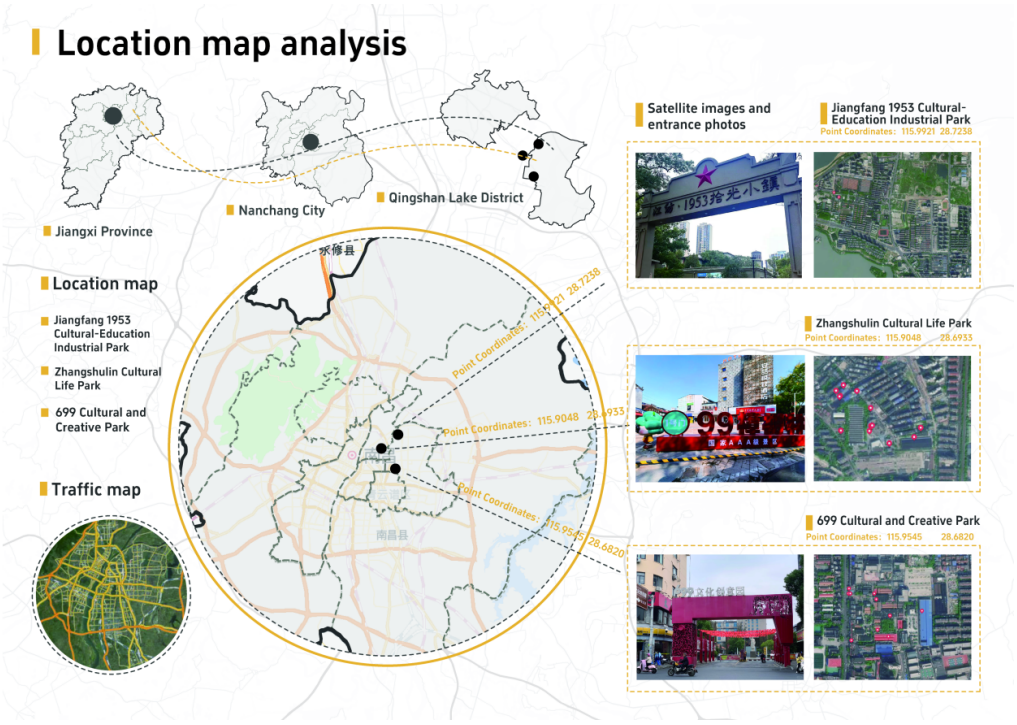


Figure 3. Location map analysis. Source: Map by the authors; photos taken by Songqi Gui (2025)

Table 9. Analytic hierarchy process-based hierarchical structure and elements

Level	Elements	Notation	Description
Goal	Composite ranking of site-selection priority	—	Adaptive-reuse site selection in Nanchang
Criteria	HV, CV, AC, DP, SI, EE, ES	c	Seven first-tier criteria (Table 4)
Alternatives	699; ZSL; JF 1953	I = 1, 2, 3	Three candidate sites for evaluation

Abbreviations: 699: Nanchang 699 Creative Park; AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; JF 1953: Jiangfang 1953; SI: Social impact; ZSL: Zhangshulin Cultural Life Park

stability and heterogeneity of the results.

4.1. Sampling and instruments

Respondents were divided into experts and public stakeholder groups. At the criteria level, the public provided 1–5 pairwise judgments mapped to the AHP subset {1,2,3,4,5}. At the alternative level, a 1–2–3 quick ranking was converted to weights using the rank–reciprocal rule (**Equation 5**). Templates and quotas are provided in Supplementary C1 and C2. Experts (n = 9) were recruited purposively and via snowball sampling through professional networks, each with ≥10 years of experience. The public sample was recruited using multi-channel convenience sampling (paper + WeChat H5), with role quotas and visit-frequency checks. All data were de-identified and encrypted. Return rates were as follows: experts 9/9 valid; public 15 distributed, 12 valid, of which 6 formed the representative alternative-level subsample (Tables 8, 10, and 11).

4.2. Quality control and synthesis

To ensure data quality, CR ≤ 0.10 (RI = 1.36 for n = 7; RI = 0.52 for n = 3) was required for data acceptance using **Equations 1 and 2**, with a one-time review allowed for failures (Section 4.2, Table 7). Parallel administration enforced completeness and ensured unique 1–2–3 ranks (Supplementary C4, Table S13). Abnormal response times triggered automatic prompts for verification. Processing included structured error checks, AHP consistency testing, and weight conversion and synthesis (Table 12). A ≥ 90 percent completeness rule led to the exclusion of two public cases with missing items and one case with tied ranks, leaving 12 valid public responses. All nine expert matrices and all twelve public 7 × 7 criteria matrices passed the CR ≤ 0.10 threshold. Public alternative weights were derived using rank-reciprocal mappings (**Equation 5**), while expert 3 × 3 matrices also met CR ≤ 0.10. Integrated criterion weights were computed using the weighted fusion formula (**Equation 7**), holding conditional weights fixed where needed for sensitivity analysis (**Equation 8**).

4.3. Robustness and subgroup checks

A three-level AHP hierarchy (goal–criteria–alternatives) was used with seven criteria (HV, CV, EE, DP, AC, SI, ES) and three alternatives (699, ZSL, JF 1953), with definitions and 1–5 anchors provided in Table 6. Experts completed a

Table 10. Sampling frame and recruitment overview

Population type	Sampling and sources	Planned	Distributed (valid)
Experts	Purposive + snowball; targeted invitations via conferences, associations, design institutes, parks	8–12	9 (9)
Public (criteria level)	Convenience + on-site interception + residents' committee	12–15	15 (12)
Public (alternative subsample)	Selected from 12 by role + visit frequency	6	6 (6)

Table 11. Overview of data-collection modes and tools

Group	Tools and delivery	Mandatory checks	QC metadata (No PII)	Incentive and duration
Experts (Delphi and AHP)	On-site paper; encrypted e-forms (email/link)	Completeness; CR ≤ 0.10	Anonymous ID; timestamp; device; source	No honorarium; ~5–8 min
Public (criteria Likert; alternative 1–2–3)	A4 paper (on-site); WeChat H5 mini-program	Completeness; unique 1–2–3; instant prompts	Anonymous ID; start/end time; device; source	Small gift; ~5–7 min

Abbreviations: AHP: Analytic hierarchy process; CR: Consistency ratio; PII: Personally identifiable information; QC: Quality control

Table 12. Data-cleaning rules and exclusions

Rule	Target	Excluded	Retained	Notes
Completeness ≥ 90%	Public	2	12	One online, one paper below threshold
Unique 1–2–3 ranking	Public	1	12	Tied ranks excluded
De-duplication (keep latest)	Experts and Public	0	Experts 9; public 12	System + manual checks
AHP consistency (CR ≤ 0.10)	Experts	0	9	Methods/thresholds: Supplementary C3

Abbreviations: AHP: Analytic hierarchy process; CR: Consistency ratio

7 × 7 matrix using the 1–9 scale, while the public produced 7 × 7 matrices through 1–5 mapping to the AHP subset and reciprocals. Priorities were obtained via the eigenvector method with coherence verified using CI/CR (accepting CR ≤ 0.10; **Equations 1 and 2**; RI = 1.36 for $n = 7$, 0.52 for $n = 3$). Expert matrices were aggregated using AIJ, and public priorities were aggregated using AIP (**Equation 4**). Global criterion weights were then computed as in **Equation 7**:

$$\mathrm{w} = \alpha \mathrm{w}^{\mathrm{E}} + (1-\alpha)\mathrm{w}^{\mathrm{P}} \tag{7}$$

Consistency statistics are reported in Supplementary C5, and summary weights in Table 13. Under each criterion, experts provided 3 × 3 comparisons, aggregated using AIJ with CR ≤ 0.10. Public 1–2–3 alternative rankings were converted to weights using the rank–reciprocal rule with constants (6/11, 3/11, 2/11). Table 14 presents the fused conditional weights. Composite scores were computed as in **Equation 8**:

$$\mathrm{S_i} = \sum\nolimits_{\mathrm{c}\in\{\mathrm{HV,CV,AC,DP,SI,EE,ES}\}} \mathrm{w_c}\ \mathrm{w_{c,i}} \tag{8}$$

In the above equation, W_c is the global weight of criterion c, and W_{ci} is the conditional weight of alternative i under c. Scores and rankings are presented in Table 15.

4.4. Robustness and heterogeneity checks

Robustness was assessed using three approaches: (i) CI/CR consistency testing, (ii) OAT weight sensitivity analysis, and (iii) diagnostics of expert–public differences. These procedures followed established AHP and MCDA best practices (Ferretti *et al.*, 2014; Forman & Peniwati, 1998). For AC, two objective proxies—straight-line distance to the city center and walking distance to the nearest metro station—were used solely for cross-validation (Supplementary E1).

4.4.1. Consistency testing

It is noted here that all matrices passed CI/CR screening according to **Equations 1 and 2**. For the expert group, λ_{max} = 7.232, CI = 0.039, and CR = 0.028. For the public group, λ_{max} = 7.032, CI = 0.005, and CR = 0.004. Summary details are provided in Table 16.

4.4.2. One-at-a-time weight sensitivity

Starting from the global weight vector W = [wHV,wCV,wAC,wDP,wSI,wEE,wES], each criterion was perturbed individually by factors f∈{0.90,0.95,1.05,1.10} followed by renormalization (**Equation 9**):

$$\mathrm{w'_c} = \frac{\mathrm{fw_c}}{1+(\mathrm{f}-1)\mathrm{w_c}},\quad \mathrm{w'_j} = \frac{\mathrm{w_j}}{1+(\mathrm{f}-1)\mathrm{w_c}}(\mathrm{j}\neq\mathrm{c}) \tag{9}$$

Composite scores were recomputed using linear aggregation (**Equation 10**):

$$\mathrm{S_i} = \sum\nolimits_{\mathrm{c}} \mathrm{w_c w_{c,i}} \tag{10}$$

Scenario grids and scripts are documented in Supplementary D2 and D5.

4.4.3. Group differences and fusion weights

Expert priorities were aggregated using AIJ, while public priorities were aggregated using AIP (**Equation 4**). Global criterion weights were computed using a linear fusion with α = 0.70 (experts: public). Welch's *t*-tests (α = 0.05) and Cohen's *d* effect revealed that experts assigned higher weights to HV and ES (large effects), while the public emphasized CV, AC, SI, and EE (medium–large effects). No significant difference was observed for DP. Detailed statistics are reported in Section 4 and Supplementary D3, with a method summary in Table 17.

4.4.4. Method validation and numerical stability

Based on the data obtained, all matrices satisfied reciprocity and the CR ≤ 0.10 threshold. All weight vectors and composite scores summed to 1 within rounding precision. Pearson correlation analyses with Holm–Bonferroni correction, together with no-intercept variance inflation factors (VIFs; ranging 1.33–1.89), indicate limited redundancy and stable numerical behavior. A compact checklist is presented in Table 18.

Table 13. Global criterion weights

Group/criterion	HV	CV	AC	DP	SI	EE	ES	Total
Experts	0.320	0.134	0.045	0.080	0.115	0.055	0.251	1.000
Public	0.184	0.202	0.103	0.102	0.174	0.107	0.128	1.000
Global (70:30)	0.279	0.154	0.062	0.087	0.133	0.071	0.214	1.000

Abbreviations: AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; SI: Social impact

Table 14. Conditional weights of alternatives

Criterion	699	ZSL	JF 1953
HV	0.214	0.147	0.639
CV	0.229	0.144	0.627
AC	0.614	0.155	0.231
DP	0.267	0.111	0.621
SI	0.302	0.109	0.588
EE	0.594	0.112	0.293
ES	0.128	0.609	0.263

Notes: Public alternative inputs derived from six representative cases, equally weighted; Rank–reciprocal mapping enforced unique ranks; Row sums may vary by ± 0.001 due to rounding.
Abbreviations: 699: Nanchang 699 Creative Park; AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; JF 1953: Jiangfang 1953; SI: Social impact; ZSL: Zhangshulin Cultural Life Park

Table 15. Composite scores and ranking

Site	Expert	Public	Global weighted	Rank
Nanchang 699 Creative Park	0.2435	0.3180	0.2659	2
Zhangshulin Cultural Life Park	0.2309	0.2467	0.2356	3
Jiangfang 1953	0.5256	0.4353	0.4985	1

Table 16. Summary of consistency statistics

Level/group	*n*	RI	λ_{max}	CI	CR	Decision
Criteria (experts)	7	1.36	7.232	0.039	0.028	Pass
Criteria (public)	7	1.36	7.032	0.005	0.004	Pass
Alternatives (HV)	3	0.52	3.010	0.005	0.010	Pass
Alternatives (CV)	3	0.52	3.001	0.000	0.001	Pass
Alternatives (AC)	3	0.52	3.002	0.001	0.002	Pass
Alternatives (DP)	3	0.52	3.054	0.027	0.052	Pass
Alternatives (SI)	3	0.52	3.058	0.029	0.056	Pass
Alternatives (EE)	3	0.52	3.021	0.010	0.020	Pass
Alternatives (ES)	3	0.52	3.038	0.019	0.037	Pass

Notes: CI/CR formulas and RI values are reported in Supplementary C3; Matrix-level summaries are presented in Supplementary C5. Public alternative weights were derived from rank–reciprocal mappings (Supplementary C4; CR not applicable).
Abbreviations: AC: Accessibility; CI: Consistency index; CR: Consistency ratio; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; RI: Random index; SI: Social impact

Table 17. Group aggregation, difference testing, and fusion

Module	Data objects	Procedure	QC/thresholds
Aggregation (experts)	Pairwise judgment matrices	AIJ: geometric mean → group matrix → priorities	CR ≤ 0.10; RI: $n = 7 \rightarrow 1.36$, $n = 3 \rightarrow 0.52$
Aggregation (public)	Criterion priority vectors; alternative ranks	AIP (criterion vectors); alternative-level rank–reciprocal + normalization	Unique ranks; no missing items
Difference testing	Experts vs. public (seven criteria)	Welch's t ($\alpha = 0.05$) + Cohen's d	Standard significance and effect-size rules
Fusion	Global criterion weights	Linear weighting 70:30 (experts: public)	Baseline for synthesis and OAT

Note: Full test statistics (t, p, d) are provided in Supplementary D3.
Abbreviations: AIJ: Aggregation of individual judgments; AIP: Aggregation of individual priorities; CR: Consistency ratio; OAT: One-at-a-time; QC: Quality control; RI: Random index

4.5. Indicator system and weight distribution

A three-level AHP (goal–criteria–alternatives) with seven criteria (HV, CV, AC, DP, SI, EE, ES; Table 6) was implemented. Expert 7 × 7 matrices, aggregated using AIJ, passed consistency checks (CR = 0.028; λ_{max} = 7.232; CI = 0.039). Experts emphasized HV and ES, which together accounted for 57.1 percent of the total weight, while AC and EE each contributed approximately 10 percent (Table 19). Public matrices (n = 12), derived from the 1–5 mapped subset and aggregated via AIP, also passed consistency (CR = 0.004; λ_{max} = 7.032; CI = 0.005), prioritizing CV, HV, and SI and assigning relatively higher shares to AC and EE (Table 19). Fusing expert and public weights at α = 0.70 yielded global weights as follows: HV 0.279 > ES 0.214 > CV 0.154 > SI 0.133 > DP 0.087 > EE 0.071 > AC 0.062 (Table 13). This fusion preserved a heritage–ecology core (HV + ES = 0.493) while elevating culture–society dimensions. These global weights were applied to Sections

Table 18. In-model validation checklist and results.

Check item	Target and method	Result	Notes
Positive reciprocity	Criteria-level and each 3 × 3 alternative matrix	Pass	Reciprocal relationships maintained within display precision
CR	Criteria: n = 7 (RI = 1.36); alternatives: n = 3 (RI = 0.52)	Pass	Experts CR = 0.028; public CR = 0.004; all alternative 3 × 3 matrices CR < 0.10
Weight normalization	All weight vectors	Pass	Dum of weights (Σw = 1) (four decimal places)
Score normalization	Three composite scores	Pass	0.2659 + 0.2354 + 0.4986 ≈ 1.0000
Linear synthesis check	Example with HV	Pass	Composite scores match table values
OAT stability	Each criterion perturbed ± 5%, ± 10% (renormalized)	Stable	No rank reversals observed
Precision and rounding	Double precision; four decimal places	Compliant	Reproducible across calculations

Note: More details are included in Supplementary C3, C5, and D2.
Abbreviations: CR: Consistency ratio; HV: Historical value; OAT: One-at-a-time; RI: Random index

Table 19. Expert and public criterion weights

Group	Criterion						
	HV	CV	AC	DP	SI	EE	ES
Expert	0.320	0.134	0.045	0.080	0.115	0.055	0.251
Public	0.184	0.202	0.103	0.102	0.174	0.107	0.128

Note: CR ≤ 0.10.
Abbreviations: AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; SI: Social impact

4.2 and 4.3, and underpinned the stability in Section 4.4. Group-level consistency statistics are summarized in Table 16; repeated values are omitted for clarity.

4.6. Alternative-level weights and composite scores

Conditional weights under each criterion were derived from expert 3 × 3 pairwise matrices using AIJ aggregation (**Equation 3**). Public weights were obtained from 1–2–3 rankings and converted via the rank–reciprocal rule (**Equation 5**). Composite scores were computed through linear aggregation of global criterion weights and conditional weights (**Equation 7**). Expert conditional weights indicate that JF 1953 leads on HV, CV, SI, and DP; 699 leads on AC and EE; and ZSL leads on ES. All expert group matrices satisfied CR ≤ 0.10. Using expert criterion weights, expert-only composite scores ranked the sites as follows: JF 1953 = 0.5241 (1st), ZSL = 0.2523 (2nd), and 699 = 0.2236 (3rd). Public conditional weights, converted from strict 1–2–3 rankings (6/11, 3/11, 2/11), show a similar pattern. JF 1953 ranks first on HV, CV, and DP; 699 ranks slightly higher on SI and clearly leads on AC and EE; ZSL ranks first on ES. Using public criterion weights, public-side composite scores are: JF 1953 = 0.4353 (1st), 699 = 0.3180 (2nd), and ZSL = 0.2467 (3rd). Matrix CI/CR summaries are provided in Supplementary C5, while the rank–reciprocal construction is provided in Supplementary C4. Per-criterion conditional weights are reported in Table 13, with stakeholder roles available in Supplementary C2.

4.7. Composite alternative scores and ranking

Global composite scores were computed by applying a 70:30 expert–public fusion to both criterion and conditional weights (**Equations 5 and 7**). The fused scores were 0.4986 for JF 1953, 0.2654 for 699, and 0.2359 for ZSL. This yields a clear ranking: JF 1953 > 699 > ZSL. The score gap between the first and second sites was 0.2326, while the gap between the second and third sites was 0.0303. Additionally, it is noted that expert-only and public-only rankings aligned perfectly with the fused order, with Spearman's ρ = 1.00 and Kendall's τ = 1.00 (Table 15).

4.8. Sensitivity analysis

One-at-a-time tests were conducted by perturbing each global criterion weight by ±5 percent and ±10 percent, followed by renormalization (**Equation 8**). Composite scores were then recomputed using linear aggregation. Across all 28 (seven criteria × four perturbation levels), no rank reversals occurred. Absolute score shifts remained below 0.01 for all sites. Minimum winning margins exceeded 0.227 for every criterion, confirming robust separation between alternatives. Score bands were narrow: JF 1953 ranged from 0.4937 to 0.5038, 699 ranged from 0.2631 to 0.2690, ZSL ranged from 0.2272 to 0.2432 (Tables 20 and 21).

Table 20. Summary of ranking stability

Criterion	Minimum lead margin	Conclusion
HV	0.227170	No reversal
CV	0.230113	No reversal
AC	0.228909	No reversal
DP	0.231638	No reversal
SI	0.231986	No reversal
EE	0.228943	No reversal
ES	0.227170	No reversal

Abbreviations: AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; SI: Social impact

Table 21. Ranges of composite scores

Site	Baseline composite	Minimum	Maximum	|ΔScore|
699 Creative Park	0.2659	0.2631	0.2690	0.0030
Zhangshulin Cultural Life Park	0.2356	0.2272	0.2432	0.0082
Jiangfang 1953	0.4985	0.4937	0.5038	0.0051

4.9. Diagnostics: Correlations and variance inflation factors

Pearson correlations were computed on 21 weight vectors, including 9 experts and 12 public respondents, with Holm–Bonferroni correction applied. Two significant negative correlations were observed: HV–AC ($r = -0.73$, $p_{Holm} = 0.004$) and AC–ES ($r = -0.63$, $p_{Holm} = 0.042$). All other pairs showed $|r| < 0.60$ or adjusted $p \geq 0.05$. Given the compositional nature of the weights (non-negative, summing to 1), these negative correlations are interpreted descriptively rather than causally. In this investigation, no-intercept VIFs ranged from 1.33 to 1.89, well below common thresholds, indicating limited multicollinearity and good interpretability. Full correlation matrices are available in Supplementary D5, and VIF diagnostics are reported in Supplementary D4.

4.10. Differences between expert and public weights

Welch's two-tailed *t*-tests (α = 0.05) with Cohen's *d* were used to quantify systematic differences between expert and public weights. Experts assigned significantly higher weights to HV and ES, with large effect sizes. The public,

in contrast, assigned higher weights to CV, AC, SI, and EE, with medium–large effect sizes. It is worth noting that DP showed no statistically significant difference between groups. These complementary emphases did not alter the fused ranking reported in Section 4.3. Detailed statistics are provided in Table 22 and Supplementary D3.

Across expert-only, public-only, and fused evaluations, the site ranking consistently follows JF 1953 > 699 > ZSL. OAT sensitivity tests, with ±5 percent and ±10 percent perturbations of criterion weights, revealed no rank reversal and score shifts below 0.01. Diagnostics indicate limited redundancy and low multicollinearity, confirming the numerical stability of the analysis. Differences between expert and public judgments emphasize a heritage–ecology core while elevating cultural and social dimensions. These findings collectively support the robustness, interpretability, and credibility of the fused results.

5. Discussion

5.1. Interpretation of the prioritization patterns

The prioritization patterns observed across the three candidate sites reveal distinct redevelopment logics inherent to different types of industrial heritage projects. JF 1953 demonstrates strong performance in HV, CV, and SI, indicating that sites with high material integrity and coherent industrial narratives are particularly well-suited for heritage-led, community-oriented regeneration. In contrast, 699 excels in AC and EE, reflecting a market-driven, mobility-oriented redevelopment model where visitor footfall, transport connectivity, and commercial viability are decisive factors (Li *et al.*, 2023). ZSL, while ranking lower overall, leads in ES, highlighting the trade-offs between environmental performance and immediate redevelopment readiness. Collectively, these patterns demonstrate that industrial heritage sites are not interchangeable assets; rather, each represents a distinct strategic pathway—heritage-centered, market-oriented, or ecology-driven—associated with unique spatial, social, and economic logics. Recognizing these differentiated redevelopment strategies provides a robust foundation for translating AHP-derived priorities into actionable planning and policy interventions.

It is worth noting here that differentiated redevelopment logics identified in this work are not unique to the Nanchang context. Similar patterns have been observed in previous AHP-based evaluations of industrial heritage reuse, where experts and non-expert stakeholders tend to prioritize different dimensions of value. For instance, studies by Bottero *et al.* (2019) and Milošević *et al.* (2020) reported that experts typically emphasize heritage integrity, structural feasibility, and long-term sustainability. In contrast, public participants tend to assign greater importance to cultural experience, AC, and everyday usability. Similarly, Lian and Dimitrijević (2025) identified a comparable divergence between professional and social perspectives in the reuse of former industrial facilities in Shaanxi, a finding consistent with the framework proposed by Mieg and Oevermann (2014). The current findings replicate the observed expert–public contrast and further reveal how these differences manifest as distinct redevelopment pathways—heritage-centered, market-oriented, and ecology-driven—within a single urban context.

5.2. Strategic implications for site-specific regeneration

Building on the differentiated redevelopment logics identified, the prioritization results can be translated into site-specific strategic pathways for industrial heritage regeneration. For objectives emphasizing protection and society engagement, JF 1953 stands out as the highest-priority site. Its strong HV, CV, and SI indicate a robust capacity to sustain heritage narratives, foster community-oriented activities, and maintain ecological performance simultaneously.

Table 22. Welch's *t*-tests for expert vs. public weights

Criterion	Expert mean	Public mean	Expert SD	Public SD	*t*	*p*-value	*d*	Conclusion
HV	0.3180	0.1930	0.0526	0.0888	4.00	0.00082	1.64	Higher in experts
CV	0.1330	0.1950	0.0150	0.0744	−2.81	0.0157	−1.08	Lower in experts
AC	0.0486	0.1045	0.0132	0.0589	−3.19	0.0075	−1.23	Lower in experts
DP	0.0820	0.1058	0.0181	0.0508	−1.50	0.1542	−0.59	Not significant
SI	0.1160	0.1660	0.0213	0.0684	−2.40	0.0310	−0.94	Lower in experts
EE	0.0572	0.1150	0.0136	0.0875	−2.25	0.0442	−0.86	Lower in experts
ES	0.2490	0.1200	0.0404	0.0239	8.53	< 0.0001	4.04	Higher in experts

Abbreviations: AC: Accessibility; CV: Cultural value; DP: Development potential; EE: Economic benefit; ES: Ecological sustainability; HV: Historical value; SD: Standard deviation; SI: Social impact

In addition to its strong performance in HV, CV, and SI, JF 1953 also demonstrates solid ES performance, which plays an important supporting role in its prioritization. Given that ES represents the second-largest global weight (0.214), sites that combine strong HV with acceptable environmental performance achieve a substantial advantage in the composite scoring process. Although ZSL ranks first in ES individually, its relatively lower performance in HV, DP, and SI limits its overall prioritization potential. In contrast, JF 1953 maintains consistently high performance across the high-weight criteria combination (HV + ES), ensuring both heritage integrity and long-term environmental viability. This balanced performance strengthens the robustness of its top ranking under multiple weighting and sensitivity scenarios.

In contrast, 699 exhibits a market- and AC-driven redevelopment logic, where transport connectivity, visitor flows, and commercial viability serve as the primary performance drivers. From this perspective, measures such as first- and last-mile mobility solutions, improved wayfinding, and curated programming are not merely operational improvements, but core mechanisms through which this type of site can maximize its overall effectiveness.

In addition, ZSL represents a third redevelopment pathway, characterized by high ES but relatively lower readiness for immediate development. In this case, the prioritization results suggest that further investment decisions should be informed by the systematic collection of objective park-level data, including tenant profiles, outputs, visitor numbers, and events, to better assess the site's DP and EE.

5.3. Methodological and practical significance

Beyond the site-specific findings, the results obtained in this study demonstrate the value of integrating expert judgment with public preferences within an explicitly structured and consistency-controlled AHP framework. The clear distinction among heritage-centered, market-oriented, and ecology-driven pathways illustrates how MCDM tools can uncover trade-offs that are often overlooked when industrial heritage projects are evaluated solely based on financial feasibility or expert opinion.

From a planning and governance perspective, the framework provides a practical tool for structuring stakeholder dialogue, evaluating alternative policy priorities, and explaining the rationale behind site prioritization. Beyond its methodological application, the framework advances debates on HV trade-offs by demonstrating how expert knowledge and public preferences can be systematically reconciled within a single decision-making structure in the Chinese urban context. By linking quantified criteria to interpretable redevelopment logics, the approach promotes more accountable, transparent, and evidence-based decision-making, particularly in contexts where industrial heritage must compete with other urban development pressures.

5.4. Limitations and directions for future research

While the study yields important findings regarding site selection and redevelopment pathways for industrial heritage, several limitations should be acknowledged. First, the analysis is confined to a single city and three candidate sites, which may restrict the generalizability of the findings to other urban contexts or industrial heritage typologies. Second, public participation was implemented through a simplified ranking procedure. While this approach reduced respondent burden, it may not fully capture the complexity and nuance of stakeholder preferences. Third, robustness testing was limited to OAT weight perturbations, without incorporating more advanced probabilistic or global sensitivity analyses.

In addition, the form and depth of public participation may significantly influence evaluation outcomes. Alternative approaches—such as detailed pairwise comparisons, deliberative workshops, or stratified sampling across diverse user groups—could potentially alter the relative importance assigned to criteria such as SI, AC, or cultural experience. Similarly, involving a broader set of stakeholders (e.g., local residents, frequent users, cultural practitioners, or business operators) may uncover differentiated preference structures that are not fully captured through simplified ranking procedures. While the present study emphasizes feasibility and respondent AC, future research could investigate how variations in participation formats and stakeholder composition affect both prioritization outcomes and the robustness of decision-making.

Future research could address these limitations by applying the framework to a larger number of sites across multiple cities, adopting more detailed public preference elicitation methods, and incorporating Monte Carlo simulations or scenario-based sensitivity analyses. Furthermore, integrating richer objective data on AC, economic performance, and environmental impact would enhance the analytical foundation and robustness of industrial heritage prioritization.

6. Conclusion

This study develops an auditable AHP-based MCDA framework that integrates expert pairwise judgments (AIJ) with public inputs (criterion-level pairwise mapping and

alternative-level rank–reciprocal transformation) under explicit consistency control (CR ≤ 0.10) and a predefined fusion rule (70:30, α = 0.70). When applied to JF 1953, 699, and ZSL, the fused composite scores (0.4985, 0.2659, 0.2356) yield a stable ranking: JF 1953 > 699 > ZSL.

Jiangfang 1953 is the strongest in HV/CV/SI, 699 in AC/EE, and ZSL in ES. OAT weight perturbations (±5%, ±10%) do not change the ranking, with |ΔScore| < 0.01. Pearson correlations with Holm–Bonferroni correction and no-intercept VIFs indicate low redundancy and limited multicollinearity.

Methodologically, the study operationalizes a transparent and reproducible expert–public MCDA workflow with an explicit fusion rule and a compact verification loop (consistency screening, sensitivity analysis, correlation diagnostics, and VIF checks), which is extensible to portfolio-level heritage decision-making.

Practically, the workflow is directly deployable for agencies and planners, supporting pre-screening, participatory weighting, robustness verification, and scenario-based reweighting. Based on the findings, JF 1953 should be prioritized to consolidate HV/CV/SI; 699 should be positioned as an access- and economy-oriented driver; and ZSL should be developed for ecological and community functions supported by standardized park-level ledgers. To strengthen governance and long-term use, it is recommended to:

(i) adopt the fused ranking as a near-term allocation baseline;
(ii) stage site portfolios strategically across the three sites;
(iii) institutionalize annual performance ledgers (access, tenants, output, taxes, footfall, events); and
(iv) replace one-off surveys with longitudinal expert–public panels to track preference shifts and their impacts.

Acknowledgments

The authors sincerely thank Universiti Sains Malaysia, School of Housing, Building & Planning, for providing administrative and technical support throughout this study. We acknowledge the Nanchang Municipal Bureau of Natural Resources and the Nanchang Municipal People's Government for granting access to planning materials that informed the contextual review conducted in this study. Field access and practical insights provided by the management teams of Jiangfang 1953, Nanchang 699, and Zhangshulin Cultural Life Park are deeply appreciated. The research also benefited from the time and expertise of our Delphi panel, which included representatives from universities, institutes, government/subdistrict offices, design firms, enterprises, and park operators. We extend our gratitude to the public respondents who completed the on-site and WeChat H5 surveys. We also thank colleagues who assisted with data entry, geographic information system validation, and quality checks.

Funding

None.

Conflict of interest

The authors declare they have no competing interests.

Author contributions

Conceptualization: Mohd Jaki Bin Mamat
Data curation: Songqi Gui
Formal analysis: Songqi Gui
Investigation: Songqi Gui
Methodology: Songqi Gui
Project administration: Mohd Jaki Bin Mamat
Resources: Songqi Gui
Software: Songqi Gui
Supervision: Mohd Jaki Bin Mamat
Validation: Mohd Jaki Bin Mamat
Visualization: Songqi Gui
Writing–original draft: Songqi Gui
Writing–review & editing: Mohd Jaki Bin Mamat

Ethics approval and consent to participate

This study involved only adult participants aged 18 years or older, and informed consent was obtained from all participants. According to applicable institutional guidelines and local regulations, ethical review and approval were not required for this low-risk social survey and field observation study.

Consent for publication

No identifiable personal data or images were included in the manuscript.

Availability of data

Data presented in this study are available upon request from the corresponding author. Data are not publicly available due to privacy concerns related to the residents involved.

References

Belton, V., & Stewart, T. J. (2002). *Multiple criteria decision analysis: An integrated approach.* New York, NY: Springer. https://doi.org/10.1007/978-1-4615-1495-4_11

Bouaziz, S., & Guechi, I. (2024). Assessing the reuse potential of industrial heritage using GIS–AHP: A case study of El

Hamma's industrial district, Algiers, Algeria. *Indonesian Journal of Social Science Research*, *5*(2), 517–532.

https://doi.org/10.11594/ijssr.05.02.13

Bottero, M., D'Alpaos, C., & Oppio, A. (2019). Ranking of adaptive reuse strategies for abandoned industrial heritage in vulnerable contexts: A multiple criteria decision-aiding approach. *Sustainability*, *11*(3), 785.

https://doi.org/10.3390/su11030785

Buckley, J. J. (1985). "Fuzzy Hierarchical Analysis." *Fuzzy Sets and Systems, 17*(3):233–247.

https://doi.org/10.1016/0165-0114(85)90090-9

Claver, J., García-Domínguez, A., & Sebastián, M. A. (2020). Multicriteria decision tool for sustainable reuse of industrial heritage into its urban and social environment: Case studies. *Sustainability*, *12*(18), 7430.

https://doi.org/org/10.3390/su12187430

Cucco, P., Maselli, G., Nesticò, A., & Ribera, F. (2023). An evaluation model for adaptive reuse of cultural heritage in accordance with 2030 SDGs and European Quality Principles. *Journal of Cultural Heritage, 59*, 202–216.

https://doi.org/10.1016/j.culher.2022.12.002

Chen, J., Judd, B., & Hawken, S. (2016). Adaptive reuse of industrial heritage for cultural purposes in Beijing, Shanghai, and Chongqing. *Structural Survey*, *34*(4/5), 331–350.

https://doi.org/10.1108/ss-11-2015-0052

Chen, X., Jiang, L., Cheng, B., Zhang, Y., & Shi, S. (2024). Evaluating urban industrial heritage value using industrial heritage matrix AHP models: A case study of Mawei Shipbuilding in Fuzhou City. *International Review for Spatial Planning and Sustainable Development*, *12*(2), 99–118.

https://doi.org/10.14246/irspsd.12.2_99

De Gregorio, S., De Vita, M., De Berardinis, P., Palmero, L., & Risdonne, A. (2020). Designing the sustainable adaptive reuse of industrial heritage to enhance the local context. *Sustainability*, *12*(21), 9059.

https://doi.org/10.3390/su12219059

Duan, Y., Liu, J., & Zhang, L. (2020). Investigation and value characteristics of the industrial heritage of Jiangxi textile factories from the perspective of industrial archaeology. *Jiangxi Science*, *38*(1), 124–129. [in Chinese].

https://doi.org/10.13990/j.issn1001-3679.2020.01.025

Ferretti, V., Bottero, M., & Mondini, G. (2014). Decision making and cultural heritage: An application of Multi-Attribute Value Theory for the reuse of historical buildings. *Journal of Cultural Heritage*, *15*(6), 644–655.

https://doi.org/10.1016/j.culher.2013.12.007

Forman, E., & Peniwati, K. (1998). Aggregating individual judgments and priorities with the analytic hierarchy process. *European Journal of Operational Research*, *108*(1), 165–169.

https://doi.org/10.1016/S0377-2217(97)00244-0

Ge, W. C., & Dai, X. (2018). A historical investigation of Jiangxi's "Third Front" construction. Journal of Nanchang University (Humanities and Social Sciences), *49*(3), 91-97. [in Chinese]

Gallou, E., & Fouseki, K. (2019). Applying social impact assessment principles in assessing the contribution of cultural heritage to social sustainability in rural landscapes. *Journal of Cultural Heritage Management and Sustainable Development*, *9*(3), 352–375.

https://doi.org/10.1108/JCHMSD-05-2018-0037

He, H., Zheng, K., Huang, H., & Li, X. (2017). A comprehensive satisfaction evaluation after industrial heritage reuse: A case of Nanchang Creative Park. *Urban Development Research*, *24*(2), 129–134. [in Chinese]

Hwang, C.-L., & Yoon, K. (1981). *Multiple attribute decision making: Methods and applications: A state-of-the-art survey*. New York, NY: Springer.

https://doi.org/10.1007/978-3-642-48318-9

Jones, C., & Munday, M. (2001). Blaenavon and United Nations World Heritage Site Status: Is Conservation of Industrial Heritage a Road to Local Economic Development? *Regional Studies*, *35*(6), 585–590.

https://doi.org/10.1080/00343400120065741

Langston, C., Wong, F. K. W., Hui, E. C. M., & Shen, L. Y. (2008). Strategic assessment of building adaptive reuse opportunities in Hong Kong. *Building and Environment*, *43*(10), 1709–1718.

https://doi.org/10.1016/j.buildenv.2007.10.017

La Rosa, D. (2014). Accessibility to greenspaces: GIS based indicators for sustainable planning in a dense urban context. *Ecological Indicators*, *42*, 122–134.

https://doi.org/10.1016/j.ecolind.2013.11.011

Li, G., Wu, S., Wen, W., & Li, S. (2023). Multi-dimensional protection and reuse of industrial heritage in the Jiangfang area of Nanchang. *Architecture & Culture*, (6), 104–107. [in Chinese]

Lian, W., & Dimitrijević, B. (2025). Analytic hierarchy process-based industrial heritage value evaluation method and reuse research in Shaanxi Province–A case study of Shaanxi Steel Factory. *Sustainability*, *17*(9), 4125.

https://doi.org/10.3390/su17094125

Liu, F., Zhao, Q., & Yang, Y. (2018). An approach to assess the value of industrial heritage based on Dempster–Shafer theory. *Journal of Cultural Heritage*, *32*, 210–220.

https://doi.org/10.1016/j.culher.2018.01.011

Milošević, D. M., Milošević, M. R., & Simjanović, D. J. (2020). Implementation of Adjusted Fuzzy AHP Method in the Assessment for Reuse of Industrial Buildings. *Mathematics,*

8(10), 1697.

https://doi.org/10.3390/math8101697

Meng, F., Zhi, Y., & Pang, Y. (2023). Assessment of the Adaptive Reuse Potentiality of Industrial Heritage Based on Improved Entropy TOPSIS Method from the Perspective of Urban Regeneration. *Sustainability*, *15*(9), 7735.

https://doi.org/10.3390/su15097735

Mieg, H. A., & Oevermann, H. (Eds.). (2014). *Industrial heritage sites in transformation: Clash of discourses* (1st ed.). London, UK: Routledge.

https://doi.org/10.4324/9781315797991

Mikhailov, L. (2003). "Deriving Priorities From Fuzzy Pairwise Comparison Judgements." *Fuzzy Sets and Systems*, *134*(3):365–385.

https://doi.org/10.1016/s0165-0114(02)00383-4

Nadkarni, R. R., & Puthuvayi, B. (2020). A comprehensive literature review of Multi-Criteria Decision Making methods in heritage buildings. *Journal of Building Engineering, 32*, 101814.

https://doi.org/10.1016/j.jobe.2020.101814

Nanchang Municipal Bureau of Natural Resources. (2020a, June 19). *Industrial heritage protection and utilization plan for Jiangfang Textile Factory in Nanchang City* [Unpublished governmental planning document].

Nanchang Municipal Bureau of Natural Resources. (2020b, September 25). Pre-approval public notice of the "Industrial heritage protection and utilization plan for Jiangfang Textile Factory in Nanchang City". http://bnr.nc.gov.cn/ncszrzyj/ghbzpqgg/202009/749afdfc560349faa2c6c28f99c0f366.shtml [Access on April 15, 2026]

Nanchang Municipal People's Government. (2024, December 26). Li Hongjun inspects planning and construction of the former wind tunnel site. [in Chinese]. https://www.nc.gov.cn/ncszf/jrnc/202412/7a59a99f39414c9291b4103f458fc9ca.shtml. [Access on April 15, 2026]

Nesticò, A., & Somma, P. (2019). Comparative analysis of multi-criteria methods for the enhancement of historical buildings. *Sustainability*, *11*(17), 4526.

https://doi.org/10.3390/su11174526

Nocca, F. (2017). The role of cultural heritage in sustainable development: Multidimensional indicators as decision-making tool. *Sustainability*, *9*(10), 1882.

https://doi.org/10.3390/su9101882

Roy, B. (1991). The outranking approach and the foundations of ELECTRE methods. *Theory and Decision*, *31*(1), 49–73.

https://doi.org/10.1007/BF00134132

Saaty, T. L. (1980). *The analytic hierarchy process: Planning, priority setting, resource allocation*. New York, NY: McGraw-Hill.

Shipley, R., Utz, S., & Parsons, M. (2006). Does adaptive reuse pay? A study of the business of building renovation in Ontario, Canada. *International Journal of Heritage Studies, 12*(6), 505–520.

https://doi.org/10.1080/13527250600940181

Vafaie, F., Remøy, H., & Gruis, V. (2023). Adaptive reuse of heritage buildings; a systematic literature review of success factors. *Habitat International*, *142*, 102926.

https://doi.org/10.1016/j.habitatint.2023.102926

Xie, H. (2022). Research on the protection and reuse of industrial heritage in Jiangxi: A case of the Hongdu Machinery Plant site in Nanchang. *Industry and Technology Forum*, *21*(24), 213–215. [in Chinese]

Yang, Y., Yu, B., Tai, H., Shen, L., Liu, F., & Wang, S. (2021). A methodology for weighting indicators of value assessment of historic building using AHP with experts' priorities. *Journal of Asian Architecture and Building Engineering, 21*(5), 1814–1829.

https://doi.org/10.1080/13467581.2021.1971529

Yung, E. H., & Chan, E. H. (2011). Implementation challenges to the adaptive reuse of heritage buildings: Towards the goals of sustainable, low carbon cities. *Habitat International, 36*(3), 352–361.

https://doi.org/10.1016/j.habitatint.2011.11.001