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EVALUATION AND OPTIMISATION OF INTEGRATED COMMUNITY BUILDING USING MULTI-SOURCE DATA: A CASE STUDY OF PENGJIAQIAO, NANCHANG

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Abstract

In response to the prevalent issue that most Chinese communities fall short of the Integrated Community standards, this study takes Pengjiaqiao Sub-district in Nanchang as a case study. Based on the conceptual framework and construction criteria of Integrated Communities, an evaluation index system was established. Using spatial analysis methods, including ArcGIS network analysis, kernel density estimation, and inverse distance weighting, the study assesses the community's infrastructure coverage, service accessibility, and functional completeness. Results indicate significant gaps between the current conditions in Pengjiaqiao Sub-district and the required standards. In response to these findings and in consideration of residents' needs, the study proposes targeted optimisation strategies from spatial and resource allocation perspectives, providing an empirical basis for promoting Integrated Community development.

Keywords: Integrated Community, Spatial Network Analysis, Kernel Density Analysis, Inverse Distance Weighting Analysis, POI Data

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INTRODUCTION

The concept of the Integrated Community, first proposed by Academician Wu Liangyong at the 2010 Shanghai World Expo, has become a key guiding framework for urban renewal in China. While policy frameworks and conceptual models have been widely discussed, a notable gap remains in spatially explicit, empirically grounded assessments of Integrated Community performance—particularly at the neighbourhood scale. This study addresses this gap by developing and applying a multi-method GIS approach to evaluate the built environment of Pengjiaqiao Sub-district in Nanchang, a pilot city for urban renewal.

By integrating spatial network analysis, kernel density estimation, and inverse distance weighting, we quantify key aspects of community completeness—including facility distribution, service coverage, and functional configuration—against nationally recognised Integrated Community standards. This methodology not only identifies specific spatial and functional shortcomings in a representative old urban area but also demonstrates how GIS-based techniques can bridge the gap between policy goals and actionable spatial strategies.

This study contributes to the international literature on sustainable community planning by offering a replicable, data-driven evaluation model applicable to cities undergoing similar renewal processes. It advances the discussion on Integrated Communities from conceptual advocacy toward evidence-based spatial planning, with implications for GIS applications in urban regeneration contexts globally.

LITERATURE REVIEW

Integrated Community

The academic community has not yet formed a unified Integrated Community concept. Various construction standards and policy documents have defined and analysed the concept of the Integrated Community, and many scholars have expressed differing views. However, they generally agree that an Integrated community should comprehensively support citizens' living, spiritual, and cultural needs. Charlene Grant (1997) considered an Integrated Community a planning development policy and strategy, essentially a tool for achieving broader social goals rather than a theoretical construct of an ideal community aimed at improving quality of life, characterised by diversity, choice, and compact form. Jennifer Anne Kay (2001) viewed an Integrated Community as a planning approach and urban development model that emerged to address various issues caused by suburban development. This model aims to manage growth while enhancing the quality of life for residents within the community, stipulating

a series of strategies to create communities that balance land use by providing broader employment, shopping, and entertainment opportunities nearby. Jane Koh (2012) believed an Integrated Community should be an excellent place to live, work, shop, and play, meaning there are opportunities locally for food, transportation, housing, entertainment, education, retail, and employment. Hamid Iravani (2020) defined an Integrated Community as an urban planning concept that respects the needs of all residents—regardless of their income, culture, age, or ideology. Marc White (2021) researched Vancouver using data analysis, interviews, and surveys to explore the contribution of housing cooperatives to creating comprehensive, affordable, and complete communities. Wu Liangyong (2010) stated that an Integrated Community has rich connotations and is a true social community, synthesising physical and socio-cultural aspects, including hardware and software elements. It should encompass housing issues, services, security, health, education, internal and external transportation, entertainment, cultural parks, and more.

The Chinese government has issued several policies to guide the construction of Integrated Communities. These policies have significant practical implications for urban planners and policymakers. For instance, the Standards for Integrated Residential Communities (Trial)(Wei Wei,2020) defines an integrated residential community as one with comprehensive essential public services, complete convenience commercial services, adequate municipal infrastructure, ample public activity spaces, full-coverage property services, and sound community management mechanisms within a walkable range for residents, fostering a strong sense of belonging and identity. In the government document “Notice on the Implementation of the Livable Environment Construction Action Plan,” Fujian Province proposed community construction reference indicators: Six Essentials, Five Standards, Three Improvements, and One Convention (Liu He, 2017).

RESEARCH SIGNIFICANCE

Provide a practical and feasible plan for the comprehensive development of the community in Nanchang City, Jiangxi Province. Taking Pengjiaqiao Sub-district in Donghu District, Nanchang City, Jiangxi Province as an example, this paper analyses the six indicators of the integrated construction index system standard. It uses GIS to analyse the compliance of different indicators. It clarifies the current hardware deficiencies of the community. It proposes suggestions for optimising the construction of the Pengjiaqiao Sub-district community, providing a path reference for the Integrated Community construction in Nanchang City, Jiangxi Province. The comprehensive development of Pengjiaqiao Sub-district can continuously promote the city's sustainable growth. From the perspective of

community development, improving the material environment and perfecting facility configuration can constantly enhance the vitality and energy of the community, and promote its secondary development; From the perspective of cultural continuity, the inheritance of traditional culture and the creation of local culture can maintain community cultural capital, reshape community spirit, and avoid cultural discontinuity; From the perspective of residents' daily lives, creating spaces for interactive communication and organizing community activities that align with interests can promote harmonious coexistence among neighbors and enhance a sense of belonging within the community.

Standards and Indicators for Integrated Community Construction

Standards for Integrated Community Construction

The “Standards for Integrated Residential Communities (Trial)” issued in 2020 delineates the construction objectives, tasks, and resource allocation for communities. It establishes the principle of building facilities such as kindergartens and elderly service stations within a 5-10 minute walking distance, which translates to a radius of 300-500 meters. The population size should be controlled at 5,000 to 12,000 people, based on the community life circle defined by the Ministry of Housing and Urban-Rural Development of the People's Republic of China (2018). The “Five-minute Life Circle” is considered the basic unit of an Integrated Community. The Integrated Community categorises community resources into six major categories and 20 subcategories (Table 1), requiring comprehensive essential public services, complete convenience commercial facilities, adequate municipal infrastructure, ample public activity spaces, full-coverage property management, and an active community management mechanism.

Table 3: Integrated Community Supporting Facility Construction Content

Basic Public Service Facilities	Convenient Commercial Facilities	Municipal Infrastructure	Public Spaces	Property Management	Community Management
One Kindergarten	One Comprehensive Supermarket	Water, Electricity, Roads, Gas, Heating, and Communication Facilities	Public Activity Spaces	Property Management	Management Mechanisms

Basic Public Service Facilities	Convenient Commercial Facilities	Municipal Infrastructure	Public Spaces	Property Management	Community Management
One Daycare Centre	Multiple Mail and Parcel Delivery service facilities	Parking and Charging Facilities	Public Green Spaces	Property Management Service Platform	Integrated Management Services
One Senior Service Centre	Other Convenient Commercial Outlets	Slow-traffic System			Community Culture
One Community Comprehensive Service Centre		Barrier-free Facilities			
One Community Health Service Station		Environmental Sanitation Facilities			
One Community Health Service Station		Environmental Sanitation Facilities			

Source: The author has compiled and illustrated based on relevant materials (Weiwei,2020)

Definition of Integrated Community Indicators

The concept of an Integrated Community was first defined by the Fujian Provincial People's Government in the government document "Notice on the Implementation of the Livable Environment Construction Action Plan." The Integrated Community indicator system standard is summarised as Six Essentials, Five Standards, Three Improvements, and One Convention (Table 2).

Table 2: Standards for the Integrated Community Construction Indicator System

System	Indicator	Remarks
Six Essentials	One Comprehensive Service Centre	It provides essential community services, health services, elderly care services, cultural resources such as books, and a community parcel pickup point.
	One Kindergarten	Considers traffic safety for children, ensuring the entrance is not directly facing high-traffic roads.
	One Bus Stop	Ideally, it is within 500m walking distance from residential areas and has comprehensive public transport facilities.
	One Public Activity Space	Converts street corners and idle land into public activity spaces, with a focus on barrier-free facilities in ageing communities, neighbour-friendly centres, and expanding indoor public spaces in northern communities.
	One Set of Complete Municipal Facilities	Develops sponge cities and green infrastructure, including fire safety facilities, recycling bins, and public toilets. Addresses issues in old neighbourhoods, such as water discharge and electrical leakage. Promotes rainwater and wastewater separation and reuse in rural communities.
	One Convenient Slow-Traffic System	It includes pedestrian and bicycle paths. The slow-traffic system is separated from vehicle traffic, connecting community public nodes and main residential areas.
Five Standards	Appearance Improvement	No non-compliant billboards; building exteriors are clean.
	Park and Green Space Standards	Parks and green spaces are open, offering good rest areas and simple fitness facilities.
	Road Construction Standards	Maintains clear fire lanes, convenient road connections with the outside, and regulated parking
	Municipal Management Standards	Complete drainage and power systems, with rainwater and wastewater separation, centralised sewage collection and treatment, and waste sorting
	Environmental Hygiene Standards	Promotes waste sorting, provides trash bins, specifies requirements for front-door cleaning, and ensures regular cleaning.
Three Improvements	Organizational Team	Integrated Community party organisations, neighbourhood committees, and resident self-governance organisations, with a focus on training specialised and high-quality community workers
	Community Services	Improved public facilities, encouragement of community-specific activities, and fostering a spirit of community co-construction
	Co-Construction Mechanism	Broad resident participation in community management, achieving community co-construction and co-management
One Agreement	Form a Community Resident Agreement	Residents reach a consensus through discussions and formulate agreements on community hygiene, parking management, self-governance, property management, and other areas to ensure resident participation, mutual supervision, and binding regulations.

Source: The author has compiled and illustrated based on relevant materials (Liu He, 2017)

“Six Essentials” refers to having one comprehensive service station, one health service station, one kindergarten, one public activity space, one set of complete municipal facilities, and one convenient slow-traffic system.

“Five Standards” means meeting standards for appearance improvement, park green space, road construction, municipal management, and environmental sanitation.

“Three Improvements” entails improving community organisation teams, community services, and co-construction mechanisms.

“One Convention” is a residents’ convention, meaning that community residents reach a consensus on community management and construction, participating in and supervising one another.

RESEARCH METHODOLOGY

This study employs both qualitative and quantitative methods, with a focus on the Pengjiaqiao Sub-district. Pengjiaqiao Sub-district is in Donghu District, Nanchang City, Jiangxi Province, China. It is bordered by Qingshan Lake to the east, Beijing West Road to the south, Jingjiu Railway to the west, and Fudayou Embankment to the north. The total area of the jurisdiction is 5.8 square kilometres, comprising 12 communities and one neighbourhood committee.

The data for this study were sourced from the POI (Point of Interest) data of public service facilities in Pengjiaqiao Sub-district, Donghu District, Nanchang City, as of April 2024, which were scraped using Python from Gaode Maps. Each POI data entry includes the corresponding district location and category attributes. The data used in the final analysis was obtained through relevant calculations and processing.

The study area was defined based on the delineated boundaries of Pengjiaqiao Sub-district. According to the Standards for Integrated Residential Communities (Trial) (Wei Wei, 2020), the elements required to construct integrated residential communities were identified, and the POI points for each component were extracted. These elements include comprehensive service stations, kindergartens, bus stops, public activity spaces, municipal facilities, and slow-traffic systems. The residential community boundaries were delineated based on the distribution of each element and the confirmation standards of the POI points. The central location of the integrated residential community was selected as the centre of the five-minute life circle. The compliance rates of various facility elements were determined through facility relevance analysis and the selection of the five-minute life circle.

Referring to the “Notice on the Implementation of the Livable Environment Construction Action Plan,” issued by the People's Government of Fujian Province, the data acquisition of the “Six Essentials” indicator is reliable and extensive. The “Six Essentials” indicators can be spatially quantified and

evaluated in the standards for Integrated Community construction. A comprehensive assessment can be made by combining the spatial distribution of the “Six Essentials” indicators with qualitative research. If the points of supporting facilities for the basic units of the community are fully covered, the community can be defined as an Integrated Community. If the service radii of all indicators fully cover the community, it is defined as a relatively Integrated Community. If the community lacks one or more facilities or has areas where the service range of facilities is inaccessible, it is defined as an incomplete community.

ANALYSIS AND DISCUSSION

Calculation of Service Area Isochrones

An isochrone refers to the area that can be covered within a specific time from a certain point using a particular mode of transportation. Isochrones reflect travel time in geographical space and can be used to analyse urban transportation convenience (Quan Heng,2021). GIS network analysis (based on service area isochrones) utilises the national geographic road network and the base conversion road network. Isochrones can be created by assuming a walking speed of 5 km/h (Figure 1) (Ma Wenjun, 2020).

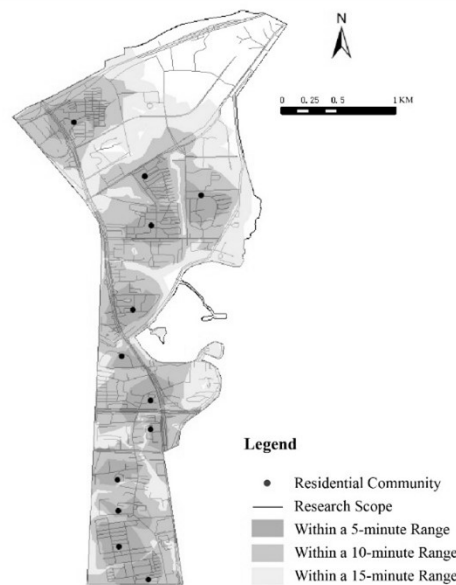


Figure 1: Isochronal Coverage Diagram

Source: illustrated by the author

Total Number of Facilities

In ArcGIS 10.5, the obtained point of interest (POI) data was visualised using the WGS 1984 coordinate system (Roslan, 2025). The coordinate system of the point layer was matched with the vector map coordinates of the Pengjiaqiao Sub-district area, and a corresponding regional POI distribution map was summarised (Liu Dandan, 2021) (Figure 2).

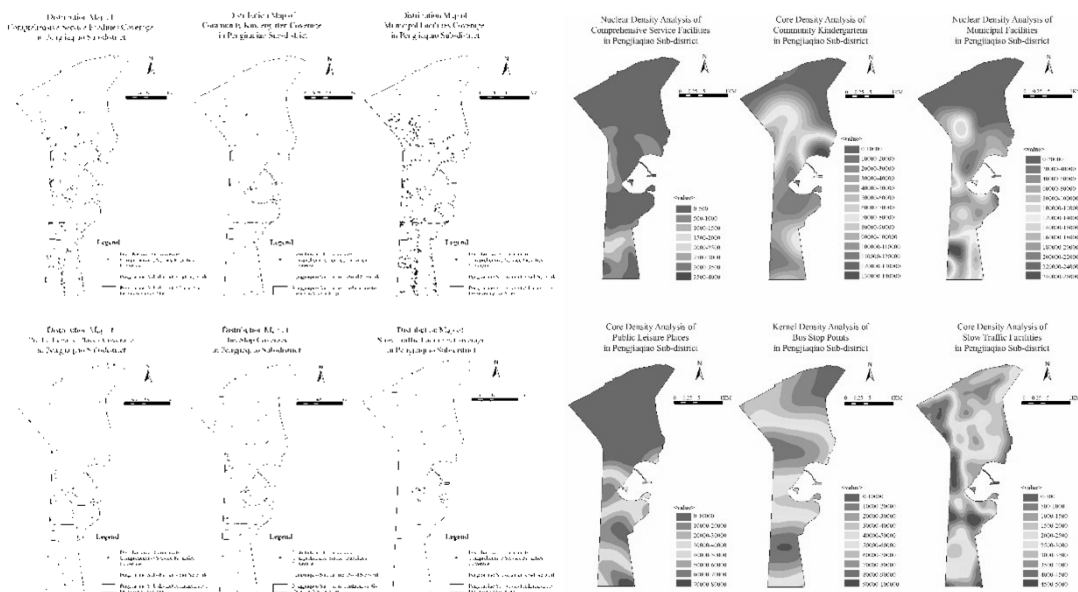


Figure 2: POI Distribution Diagram
Source: illustrated by the author

Figure 3: Kernel Density Analysis Diagram
Source: illustrated by the author

Kernel Density Analysis

The density expansion value of facility points in their surrounding neighbourhoods is calculated using kernel density analysis (Yu Wenhao, 2015). The closer the distance between elements, the higher their degree of association. The density expansion value increases as the location approaches the core element. By visualising the spatial form of the point elements, the spatial layout of each facility point within the area can be observed (Figure 3).

Inverse Distance Weighting (IDW) Method

An interpolation method uses the spatial distance between unknown and sample points as weights for weighted averaging (Zeng Jindi, 2019). The closer a sample point is to the unknown point, the higher the weight assigned to it. This paper uses this method to calculate the element coverage of the "Six Essentials"

indicators, obtain the corresponding indicators, and determine the spatial distribution of elements within the integrated residential community. The total number of facilities evaluation methods is used to assess the coverage of facilities in the central urban area, providing a data basis for subsequent facility location planning (Figure 4).

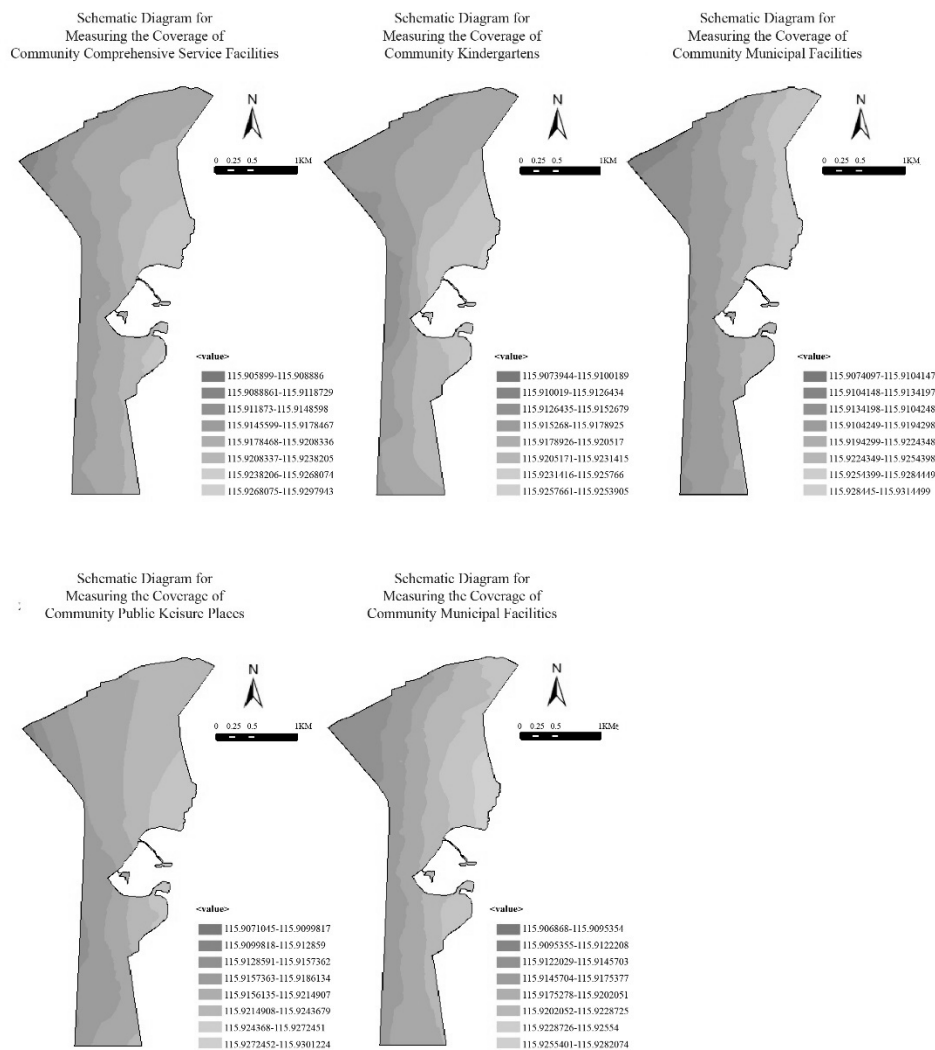


Figure 4: IDW Analysis Diagram
Source: illustrated by the author

Facility Compliance

The spatial coverage and distribution characteristics of the "Six Essentials" indicators for communities in Pengjiaqiao Sub-district are organised into six categories: comprehensive service facilities, kindergartens, municipal facilities, public recreational spaces, bus stops, and slow-traffic systems. A total of 426 points of interest were collected, including 135 comprehensive service facilities, 11 kindergartens, 248 municipal facilities, 9 public recreational spaces, 23 bus stops, and 808 segments of slow-traffic systems (Table 3).

Table 3: Analysis of "Six Essentials " Indicators

Six Essentials	The number within a 5-10 Minute Walking Range	Number of Communities Meeting the Indicator	Community Proportion	Integrated Community Proportion
Comprehensive Service Facilities	110	11	91.6%	0%
Kindergarten	4	4	33.3%	0%
Municipal Facilities	196	12	100%	0%
Public Leisure	7	5	41.6%	0%
Bus Stops	16	10	83.3%	0%
Pedestrian Traffic	2998	12	100%	0%

Source: illustrated by the author

Analysis of the Distribution of "Six Essentials" Facilities

Through a comprehensive evaluation of the "Six Essentials" indicators in the Pengjiaqiao Sub-district community, Nanchang City, it has been found that Integrated Community construction is relatively weak, and no community in Pengjiaqiao Sub-district has yet achieved the "Six Essentials" indicators. Looking at the coverage data of each indicator separately, it is relatively considerable. The configuration of municipal facilities and slow traffic communities meets the indicators, while the configuration of bus stops and comprehensive service facilities is good. However, the configuration of public leisure places and kindergartens is weak; Among them, the coverage of municipal facilities and slow traffic systems within a 5-10 minute walk meets the needs of 12 communities in Pengjiaqiao Sub-district; The distribution of bus stops and comprehensive service facilities is even and reasonable in quantity, but some communities are too large, resulting in some communities having a walking distance of more than 10 minutes from the center to the bus stop. The distribution of public leisure facilities is too concentrated and severely lacking, with a lack of public leisure facilities for residents in the southern and northern parts of the

region. The existing service radius of public leisure facilities only meets the needs of five communities.

Improvement Strategies

- i. Coordinate and Balance, Improve “Hardware” Conditions. Community life circles are the basic units of the entire city, and their everyday operation requires the coordination of community “hardware” and “software” functions. Comprehensive municipal facilities and slow-traffic systems are the main components of the "hardware" in the Pengjiaqiao Sub-district community. In promoting the construction of an Integrated Community in the Pengjiaqiao Sub-district, it is essential to complete municipal infrastructure, coordinate above-ground and underground spaces, supplement parking and charging facilities, and create barrier-free environments (Lim, 2024).
- ii. Continuous optimisation of slow-traffic systems is necessary. This includes strengthening the construction of secondary roads and walkways with slow-traffic priority, increasing the density of the slow-traffic road network, and ensuring that the width and spacing of slow-traffic roads meet the needs of pedestrians. Enhancing the accessibility of roads to provide pedestrians with more path choices is also crucial.
- iii. Focus on Local Conditions and advocate for Regional Balance. Specific enhancement and renovation strategies should be proposed to address the shortcomings of each community within the Pengjiaqiao Sub-district. The northern area has a basic configuration of bus stops with moderate accessibility. It is necessary to increase the number of bus stops in this area to improve the quality and content of public transportation services. Strengthen comprehensive service facilities, as currently, they are overly concentrated in the southern part, with fewer facilities in the northern communities.
- iv. Future community construction should also focus on building mechanisms for residential environmental management and exploring higher-quality residential construction methods. Attention should be given to vulnerable groups to achieve intergenerational coexistence. Based on the actual conditions of different areas, the number of kindergartens and elderly care homes should be increased. Relevant strategies should be proposed to optimise and renovate facilities, activity spaces, and barrier-free facilities, ensuring they meet the full needs of vulnerable groups. Expanding community life circle services should promote resilience by increasing the number, connectivity, and coverage of 5-minute life circles in Integrated Communities.

CONCLUSION

In recent years, Integrated Communities have emerged as a crucial strategy in China's urban renewal efforts. This study examines the characteristics of Integrated Communities and identifies six fundamental elements that comprise them. The GIS-based approach developed for evaluating the Integrated Community represents an established and widely adopted methodology in international urban research. Based on the evaluation index system for Integrated Communities, data analysis was conducted on Pengjiaqiao Sub-district in Nanchang City, Jiangxi Province, and optimisation strategies were proposed:

- i. A dual approach to "hardware" and "software" construction. Hardware construction primarily includes the environment, facilities, and municipal infrastructure, while software construction mainly involves urban management, services, and culture.
- ii. Identify shortcomings in community construction by comparing ArcGIS software analysis results with Integrated Community construction indicators, effectively pinpointing the deficiencies of the study object.
- iii. Provide more comprehensive facilities and services to meet residents' basic needs, focusing on vulnerable groups such as the elderly, children, and the disabled.
- iv. With the improvement in living standards, residents have new requirements for the community. Integrated Communities should meet these new demands with facilities and services such as mail and courier services, non-motorised vehicle parking facilities, and electric vehicle charging equipment.
- v. Improve community management and safety facilities, establishing a sound community management system.
- vi. Establish a GIS-based spatial analysis framework for Integrated Community assessment, providing a replicable, data-driven decision-making model for the international urban planning field and promoting the transition of community renewal from experience-based judgment to evidence-based planning.

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DISCLOSURE STATEMENT

The data for this paper were sourced from Amap POI open data.

ETHICS STATEMENT

This study utilised exclusively publicly available spatial and statistical data, which do not involve personal privacy or ethical risks. All data were processed in accordance with institutional guidelines and the principles of general ethical research.

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