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Liveability Indicator Evaluation and Optimised Development Strategies for National-Level New Areas: Evidence from Nanjing Jiangbei New Area

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Abstract

Rapid urbanisation in China has shifted the construction of new urban centres from economic expansion toward ecological integration. This study examines green construction in the Nanjing Jiangbei New Area (JNA), a national-level new area that combines a dense urban core with extensive rural townships, and sets out a framework of "top-level design–liveability indicators–demonstration projects–optimised evaluation" built on two evidence bases at different scales. An area-wide assessment scores 1169 residential communities on 30 indicators against 6711 facilities: 23 indicators count facilities inside their normative service radius, and the other seven, prescribed by the standard as life-circle configuration items rather than by distance, count facilities inside the community life circle. The assessment locates the area's binding service deficits; the township ranking is robust to alternative weights at both ends and in the urban–rural contrast, and rural ratios are reported as lower bounds. The second base examines the green building and municipal demonstration projects, which cluster in the 33.2 km^2 core area by agglomeration rather than by design, and therefore show what is feasible without sampling the whole area. The two are complementary: the diagnosis locates the deficits, and the demonstrations supply transferable pathways whose extension is conditional. The framework is a decision-support logic system, validated in direction rather than in magnitude, for the JNA and for other national-level new areas.

Keywords: liveable cities; national-level new area; liveability indicators; spatial equity; green construction; demonstration projects; urban–rural integration

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1. Introduction

1.1. Research Background

Urban liveability refers to a city's capacity to offer a good living environment and a high quality of life, a reciprocal fit between the city and its residents [1,2]. The ideal is older than the term. In China, Daoism and Feng Shui have shaped architecture and residential culture since the Zhou Dynasty (1046–221 BCE) [3], Howard (1898) proposed garden cities that combine urban and rural advantages [4], and Perry (1929) placed services

within walking distance in the neighbourhood unit, which Mumford later described as a "fact of nature" wherever people live together [5]. In China, rapid urbanisation has since produced densities that erode liveability (competition for residential space, shortages of public facilities and threats to ecological safety), and the environmental consequences of urban expansion have been quantified in meta-analytic work [6]. Sustainable, liveable cities are now treated as a major social challenge of this century [7].

National-level new areas (NNAs) are comprehensive urban areas approved by the State Council to carry out major national development and reform strategies; they help large cities optimise space, transform industry and reconcile social conflicts, and serve as models for other regions. The English term "new town" (NT) originally meant a satellite town: grounded in Perry's neighbourhood unit, the traditional NT was a large planned residential development with shops and services nearby. In China, an area is termed a "new area" as an administrative status whether it is built in a remote satellite location or next to the old town [8]. Compared with economic zones, new towns cover much larger construction areas and are planned as multi-functional, city-scale projects [9]. New town development has been adopted to optimise urban spatial structure and raise quality of life [10], and as China's cities have expanded, high-quality development, efficient governance and high-quality living have become the guidelines for urban construction [11].

Since the World Commission on Environment and Development published "Our Common Future" in 1987, sustainable development has become a central theme, addressing problems that include global warming and carbon emissions [12,13]. China has embedded the concept in urban and new area construction: in December 2016, it issued "China's Construction Plan of an Innovation Demonstration Zone for the Implementation of the 2030 Agenda for Sustainable Development" [14], proposing a demonstration zone that would offer "Chinese experience" and "Chinese solutions" transferable to other regions. New towns are central to municipal sustainability policy, and state-level new areas are the leading cases. As the world's largest energy consumer and carbon emitter, China has announced its goal to reach a carbon peak by 2030 and carbon neutrality by 2060 [15], and cities are the units that must deliver both.

With carbon peaking and neutrality as national goals, the focus of state-level new area construction is shifting from economic development to green construction under unified state planning. In 2017, for instance, China proposed developing the Xiong'an New Area as a green, nature-rich city centred on environmental protection while relieving population pressure on Beijing [16]. The financing instruments that support green building have been reviewed systematically [17].

1.2. Literature on the Evolutionary Trajectory of Liveability Assessment Frameworks

Research on liveability assessment spans architectural technology, building energy efficiency and urban planning, and combines quantitative with qualitative methods. Maslow's hierarchy of needs supplies a qualitative foundation, positing that liveability must satisfy requirements from safety and health to belonging, esteem and self-actualisation [18]. From an economic-investment angle, Xu et al. argued that investment in pollution control, often linked to higher-tax regions, has a stronger effect on rural liveability [19].

Interdisciplinary work is also common. Hazbei et al. combined urban design and ecology to examine biodiversity and liveability [20], and Riepl et al. built a liveability indicator on human-needs theory and validated it across 23 districts of Vienna [21]. Cao et al. used agent-based simulation to design governance policies for sustainable urban development [22], while Zhang et al. assessed community liveability in Shenzhen's Longgang District with POI data on safety, convenience and health [3]. Qiu et al. linked heritage preservation to liveability through collaborative governance [23], and Alipour et al. used

cluster sampling and questionnaires to show how environmental, social and economic factors shape housing liveability [24].

A parallel line of enquiry addresses urban disparity and infrastructure vulnerability with data-driven spatial models rather than composite indices. Land-use and remote-sensing variables (local climate zones, land surface temperature, impervious surface fraction) have been combined with spatial models to assess the exposure and adaptive capacity of urban infrastructure [25], and comparable approaches have characterised urban climate and its unevenness in systems of medium-sized cities [26]. These studies treat spatial disparity as a property of the built environment and of infrastructure networks. The present study shares that concern but approaches it through service accessibility rather than environmental exposure; the two perspectives are complementary and could be coupled in later work.

1.3. Research Objectives

This study examines how daily convenience, public safety and health affect urban liveability. A multi-indicator system is built and used to analyse how the dimensions interact and how each contributes to the whole. On that basis, the JNA is examined as a case, and top-down master planning, differentiated policy instruments, the demonstration effect of flagship projects and monitored liveability indicators are integrated into a framework of "top-level design–liveability indicators–demonstration projects–optimised evaluation": top-level design sets goals, indicators translate them into measurable spatial variables, demonstration projects supply empirical anchors, and evaluation feeds back into planning. Actionable recommendations are then derived for renewal and quality improvement in Nanjing.

Four questions follow. (1) Spatial equity: how does the distribution of public service facilities (education, healthcare, transportation) shape service-coverage-based liveability across sub-regions of the JNA? (2) Policy chain: how has the sequence "top-level design–liveability indicators–demonstration projects" been realised in the JNA, and what do the documentary and project evidence indicate about its coherence? (3) Transferability: under what technical, regulatory and infrastructural conditions can the green building technologies demonstrated in the JNA's model projects (passive design, photovoltaics, carbon reduction) be transferred to other projects in the new area? (4) Urban–rural integration: what industrial guidance and infrastructure investment can narrow the gap between the urban and rural parts of the JNA?

The design uses two scales. Questions (1) and (4), on spatial equity and the urban–rural gap, are answered with area-wide evidence covering the whole JNA, including its rural townships, so that the diagnosis does not depend on the core area. Questions (2) and (3), on policy implementation and technological scalability, are answered from the demonstration projects, which are spatially agglomerated. Because agglomeration is a general regularity of demonstration activity rather than an artefact of sampling, the core area is treated as a demonstration platform rather than as a sample of the whole area; the transferability of its experience is specified in Section 4.4. Each component (POI accessibility, life-circle standards, policy analysis, demonstration projects and spatial mapping) is established; the contribution lies in integrating them within the planning context of a national-level new area, and in connecting an area-wide diagnosis of service deficits to the transferability of demonstration evidence. Figure 1 summarises the framework.

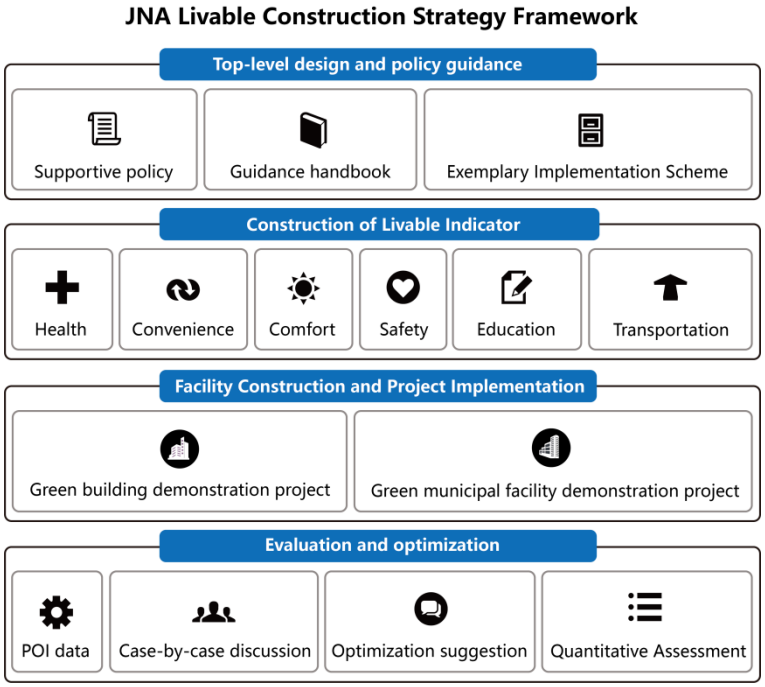


Figure 1. JNA liveable construction strategy framework.

2. Methodology

2.1. National-Level New Area and JNA

The NNAs are comprehensive urban–rural functional zones approved by the State Council to advance reform and opening-up and to promote major national development projects [27]. Construction began in the 1990s with Pudong New Area in Shanghai (1992), and by 2023 China had 19 NNAs (Table 1). Establishing an NNA is a national strategy that repositions an administrative region to promote development, providing models and facilitating resource integration. In 2016, the state-level new areas, with roughly 0.2% of the national population, generated a combined GDP of about CNY 4 trillion, some 5.4% of national output, and are an important engine of growth [28].

Table 1. List of state-level new areas in China.

No	Name	Date of Establishment	Seat of City	Seat of Province	Area/km^2
1	Pudong New Area	11 October 1992	Shanghai	/	1210
2	Binhai New Area	26 May 2006	Tianjin	/	2270
3	Liangjiang New Area	5 May 2010	Chongqing	/	1200
4	Zhoushan Archipelago New Area	30 June 2011	Zhoushan	Zhejiang	1440 (land), 20,800 (sea area)
5	Lanzhou New Area	20 August 2012	Lanzhou	Gansu	1700
6	Nansha New Area	6 September 2012	Guangzhou	Guangdong	803
7	Xixian New Area	6 January 2014	Xi'an, Xianyang	Shanxi	882
8	Guian New Area	6 January 2014	Guiyang, Anshun	Guizhou	1795
9	The West Coast New Area of Qingdao	3 June 2014	Qingdao	Shandong	2096 (land), 5000 (sea area)
10	Jinpu New Area	23 June 2014	Dalian	Liaoning	2299
11	Tianfu New Area	2 October 2014	Chengdu, Meishan	Sichuan	1578
12	Xiangjiang Area	8 April 2015	Changsha	Hunan	490
13	Jiangbei New Area	27 June 2015	Nanjing	Jiangsu	2451

Table 1. *Cont.*

No	Name	Date of Establishment	Seat of City	Seat of Province	Area/km^2
14	Fuzhou New Area	30 August 2015	Fuzhou	Fujian	1892
15	Dianzhong New Area	7 September 2015	Kunming	Yunnan	482
16	Harbin New Area	16 December 2015	Harbin	Heilongjiang	493
17	Changchun New Area	3 February 2016	Changchun	Jilin	499
18	Ganjiang New Area	14 June 2016	Nanchang, Jiujiang	Jiangxi	465
19	Xiongan New Area	1 April 2017	Baoding	Hebei	100 (at present), 2000 (plan)

The Nanjing Jiangbei New Area (JNA) lies on the northern bank of the Yangtze River and covers a planned area of 2451 km^2 with about 1.14 million residents. Established by the State Council on 27 June 2015, it is China's 13th national-level new area and the first in Jiangsu Province. It adjoins the Yangtze River Delta urban agglomeration to the east and links the Wanjiang Urban Belt with the Middle Reaches agglomeration to the west, and hosts national-level development zones, high-tech parks and universities, including Nanjing University and Southeast University. River-crossing tunnels, metro lines and port-logistics networks give it the capacity for large-scale industry and population.

Within the JNA, the core area (CAJNA), a 33.2 km^2 zone in the southwestern part of the plan, is where the green building and municipal demonstration projects are concentrated. The JNA as a whole is a node in the integrated development of the Yangtze River Delta, strengthening Nanjing's role as a regional centre and supporting high-quality development along the Yangtze Economic Belt, so its model has demonstrative value for comparable new areas. Two scales are distinguished throughout: the JNA, the scope of the area-wide assessment, and the CAJNA, where the demonstration evidence of Sections 3.3 and 4.3 is located.

2.2. Research on Liveability Control Methods Based on New District Planning and Policies

This study gathered and analysed authoritative material from official sources: national supportive policies for the new district, project details and progress reports from the JNA Management Committee, the Nanjing Municipal Government website and the JNA's official social media channels (WeChat, Douyin and Baidu). With the Technical Development Center of the Jiangsu Provincial Department of Housing and Urban-Rural Development, we co-authored the Achievements Report on Green Building in the Core Area of Nanjing JNA (2021–2023), which supplied data on completed green building and green infrastructure projects and on initiatives such as the Green City Design Handbook.

A systematic review of these materials identifies the key focuses of planning and construction in the JNA and the new projects or initiatives that can raise its liveability. Table 2 groups these documents by type, release date and core planning concept into supportive policies, guiding handbooks and exemplary implementation schemes.

Table 2. Policies and construction guidance related to liveability construction.

Name of Policy	Release Time	Key Construction
Nanjing CAJNA Green Building Special Plan	2020	Green building, water resource treatment, life convenience, energy conservation
Technical Manual for Green City Design in the CAJNA	2021	Public transportation, water resource treatment, energy conservation

Table 2. *Cont.*

Name of Policy	Release Time	Key Construction
Action Plan for High Quality Development of Green Buildings in JNA	2021	Green building, energy conservation
Nanjing JNA Opinions on the Construction of "Dual Carbon" Demonstration Schools	2021	Green building, energy conservation
Nanjing JNA Carbon Peak and Carbon Neutrality Action Plan	2022	Green building, life convenience, energy conservation, public transportation
Nanjing Municipal Sponge City Construction 14th Five-Year Plan	2022	Water resource treatment, life convenience
Comprehensive Transportation Planning of Nanjing JNA	2024	Public transportation, life convenience
Achievement Collection of Green Urban Area in the CAJNA	2024	Green building, life convenience, energy conservation

2.3. Spatial Data Acquisition

We collected Point-of-Interest (POI) data for all residential communities in the JNA from the Anjuke Real Estate website, covering villas and standard communities and recording community name, completion date and textual address. A Python (V3.8) script called the Amap (Gaode) geocoding API was implemented to retrieve coordinates; joined with the administrative directory of the JNA, the same procedure also returned rural residential data. After removing duplicates and records with missing coordinates or attributes, 1171 valid units—urban and rural, completed in 2023 or earlier—were geocoded, and the 1169 whose coordinates fall inside the JNA boundary were retained (Figure 2).

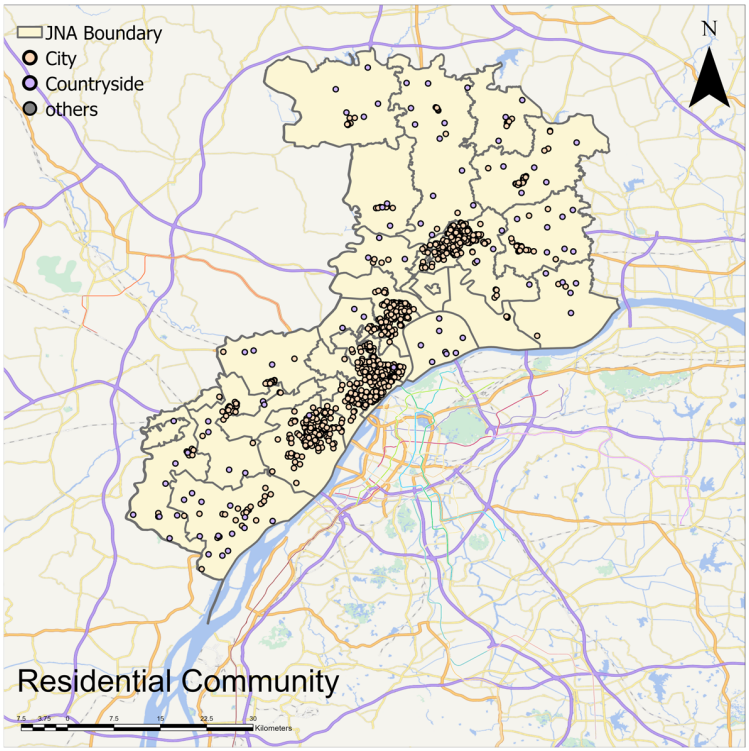


Figure 2. Residential community data point of JNA.

Data on key polluting enterprises came from the official website of the JNA Management Committee; as of 2021 there were 149 such units, geocoded in the same way.

To characterise the service environment, a facility POI database covering the whole JNA was compiled from two commercial platforms, the Amap and Baidu Map open platforms, through Python scripts querying their Web Service APIs. Duplicates were removed by matching names together with coordinates, and every entry was constrained to the study area by a point-in-polygon test. Because keyword queries under-retrieve facilities in rural townships, a second and independent collection used the polygon-search interface of the same platform, in which the retrieval region is the administrative boundary of each township rather than a keyword; all twenty-five administrative units were covered. One of them, the Nanjing Chemical Industrial Park, contains no mapped residential community and therefore did not enter the township-level aggregation, which rested on the remaining twenty-four subdistricts and towns. That round returned 3356 raw records, of which 1869 survived the same screening and were merged into the database. It was effective mainly for amenities previously missing from the rural layers—waste collection and sports facilities in particular—and returned no additional valid record for primary schools, junior secondary schools or kindergartens (Section 2.4). The resulting database contains 6711 facilities in 30 POI layers that correspond one-to-one with the 30 indicators of Table 3. The 28 indicators of the original design account for 5836 of them; public toilets (634) and bank outlets (241), both configuration items of the community life circle, were collected in the same rounds and entered the index as two further indicators. Each record was verified by reciprocal geocoding: facility name and full textual address were geocoded independently, and only records for which both results coincided were kept. Coordinates were also reverse geocoded, and records resolving only to an administrative seat (a district or township government office or a community service centre) were discarded as fallbacks. The JNA boundary was taken from the OSM data platform [29]: after narrowing the data for China to the Nanjing region, Pukou District and Liuhe District were combined with Baguazhou Subdistrict of Qixia District. The database was exported in xlsx format with Pandas and analysed in ArcGIS Pro. Advances in GIS and multi-source big data now allow X-minute community life circles to be analysed and environmental features within activity spaces, such as green space coverage and subway density, to be measured [30,31].

Table 3. Service radius and measurement basis of the liveability indicators.

Liveability Factor	Indicator Number	Service Type	Standard	Measurement	Reference
Health	1	Hospital/general hospital	≤1000 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.1
	2	Clinic/outpatient department	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.2
	3	Community health service station	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.2
	4	Pharmacy/health care	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.2
	5	Elderly care institution	≤1000 m	Life circle	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.1 (15 min life circle)
	6	Community day-care centre for the elderly	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.2

Table 3. *Cont.*

Liveability Factor	Indicator Number	Service Type	Standard	Measurement	Reference
Convenience	7	Supermarket/convenience store	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Tables C.0.1, C.0.2
	8	Retail shop	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.1
	9	Farmers' market	≤500 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.1
	10	Postal outlet	≤1000 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.1
	11	Restaurant/catering	≤500 m	Life circle	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.1 (10 min life circle)
	12	Bank outlet	≤1000 m	Life circle	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.1 (15 min life circle); no service radius is prescribed, so the indicator is assessed at the life-circle scale
Comfort	13	Park/green space	≤500 m	Threshold	Code for Urban Green Space Planning (GB/T 51346-2019), Appendix A.0.3
	14	Urban square	≤500 m	Threshold	Code for Urban Green Space Planning (GB/T 51346-2019), Appendix A.0.3
	15	Cultural activity station	≤500 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.2
	16	Sports facility	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.2
Safety	17	Emergency shelter	≤500 m	Threshold	Code for Design of Disasters Mitigation Emergency Congregate Shelter (GB 51143-2015)
	18	Police station	≤1000 m	Life circle	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.1 (15 min life circle)
	19	Fire station	≈1400 m	Threshold	Code for Planning of Urban Fire Control (GB 51080-2015)
	20	Waste collection point/station	≤70 m/≤400 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Tables C.0.1, C.0.2
	21	Recycling station	≤300 m	Life circle	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.2 (5 min life circle)
	22	Public toilet	≤300 m	Threshold	Code for Design of Public Toilets in City (CJJ 14-2016), 4.3.1; Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.2 (5 min life circle)

Table 3. *Cont.*

Liveability Factor	Indicator Number	Service Type	Standard	Measurement	Reference
Education	23	Kindergarten	≤300 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.2
	24	Primary school	≤500 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.1; Design Standard for Primary and Secondary Schools (GB 50099-2011)
	25	Junior secondary school	≤1000 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table B.0.1; Design Standard for Primary and Secondary Schools (GB 50099-2011)
	26	High school	≤1000 m	Life circle	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table 5.0.3 (district-level provision); retained as a researcher-defined indicator outside the life-circle provisions
	27	Higher education	≤1000 m	Life circle	Not covered by GB 50180-2018; retained as a researcher-defined indicator, assessed at the 15 min life circle
Transportation	28	Subway station	≤800 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.1
	29	Bus station	≤500 m	Threshold	Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), Table C.0.1
	30	Parking lot	≤300 m	Threshold	Standard for Urban Parking Planning (GB/T 51149-2016)

2.4. Data Quality Control and Validation

Three quality-control procedures were applied. First, all textual addresses were matched against the official administrative directory of the JNA, so that every facility could be assigned to a township or subdistrict and facilities in rural areas were not lost at the boundary. Second, an automated rule removed duplicates and coordinates outside the study area or coinciding with an administrative centre, a pattern characteristic of failed geocoding. Third, residual records (those whose name-based and address-based results disagreed, or that carried generic names) were reviewed individually and kept only when address and position were mutually consistent. The same procedures were applied to the boundary-based round, so both rounds were screened on identical criteria and together yielded the final 6711 facilities. For primary schools, junior secondary schools and kindergartens, the boundary-based round returned no additional valid record, with the entries retrieved for these categories being residential compounds, apartments or unrelated premises that the name-plausibility screen removed; the zero coverage of these indicators in some rural units therefore reflects the absence of a registered facility rather than an omission in the collection. Because automated collection was less complete in rural townships, the coverage ratios of Section 3.1 are relative measures of provision rather than an absolute inventory, and for rural townships they are lower bounds.

3. Results

3.1. Liveable City Factors Analysis

The assessment rests on Chinese residential planning regulations, most notably the Standard for Planning and Design of Urban Residential Areas (GB 50180-2018), which introduces the "Community Life Circle" (CLC) and divides residential areas into 5, 10 and 15 min walking scales [32]. Walking is used because it is universally accessible, environmentally sustainable and beneficial to physical and psychological health [33]. A community life circle is the urban unit within which residents' daily needs (commuting, retail, healthcare and leisure) are met on foot; the standard sets the three scales at about 300 m, 500 m and 800–1000 m of walking distance and at service radii of no more than 300 m, 500 m and 1000 m. The life-circle vocabulary is retained because it is the standard's own, but the thresholds are applied geometrically to the POI database: facilities are buffered by their normative radius, or residential units by the radius of the tier at which an item is required, and no walking time or route choice is simulated. The buffers are therefore regulatory catchments rather than pedestrian travel times. Following the construction priorities of the JNA's supportive policies and the basic elements of residential planning, services are grouped into six dimensions—Health, Convenience, Comfort, Safety, Education and Transportation—operationalised through 30 facility indicators (six, six, four, six, five and three, respectively). Of these, 23 carry a normative service radius and form the threshold indicators; the other seven are prescribed as configuration items of a given life-circle tier rather than by walking distance. Table 3 gives the radius, measurement rule and normative basis of each, and Section 3.2 sets out how the two groups are combined. The facility categories of Section 2.3 are mapped onto the indicators one-to-one, so that each indicator is measured by an independent, externally verifiable POI layer.

Spatial analysis shows a marked heterogeneity in the distribution of communities. Clusters concentrate in the southeastern subdistricts of Jiangpu, Dingshan and Yanjiang, close to the main urban area of Nanjing. Kernel density estimation was applied to the community points and the administrative boundary, projected to CGCS2000 3-degree Gauss–Kruger zone CM 117° E, with a quartic kernel of 800 m bandwidth on a 50 m cell (Figure 3). Density declines steadily with distance from the urban core, a gradient consistent with higher urbanisation and more intensive land use near the centre, and falls from the southeast to the sparse northwest and northeast. The northwestern and northeastern hinterlands lack large-scale planned residential development and consist mainly of self-built housing, a pattern that marks a lower level of formal urbanisation and a different stage of the urban–rural transition.

Liveability is evaluated through two complementary forms of coverage measurement that together span all 30 indicators. For the 23 threshold indicators, facility coordinates are taken as centroids, buffered by the normative service radius, and a community is deemed covered if its coordinates fall inside the resulting catchment; the standards follow specific regulatory controls—for instance, the spatial configuration of hospitals and clinics under GB 50180-2018. For the remaining seven, the standard prescribes no radius, because they are regulated as configuration items that a life circle of a given tier must contain; the measurement is inverted and the residential unit becomes the reference object. A life circle is drawn around each unit at the radius of the tier at which the item is required, and the unit is credited if at least one facility of that type falls inside it. Recycling stations, required in the 5 min life circle (Table B.0.2), are evaluated at 300 m; catering outlets, required from the 10 min level upwards (Table B.0.1), at 500 m; and elderly care institutions, police stations, high schools, higher education institutions and bank outlets, provided at the 15 min level or above, at 1000 m. High schools and higher education institutions are not among the life-circle facilities of GB 50180-2018 (the former are provided at district level and the latter

lie outside residential-service provision) but are retained so that the Education dimension is assessed in full, and are evaluated at 15 min to match their district role. Table 3 summarises the radius and rule of each indicator and Table 4 lists the normative documents. All radii are straight-line distances on a projected plane; the pedestrian-network validation of Section 3.2 quantifies how far this departs from walking distance and whether the departure is evenly distributed.

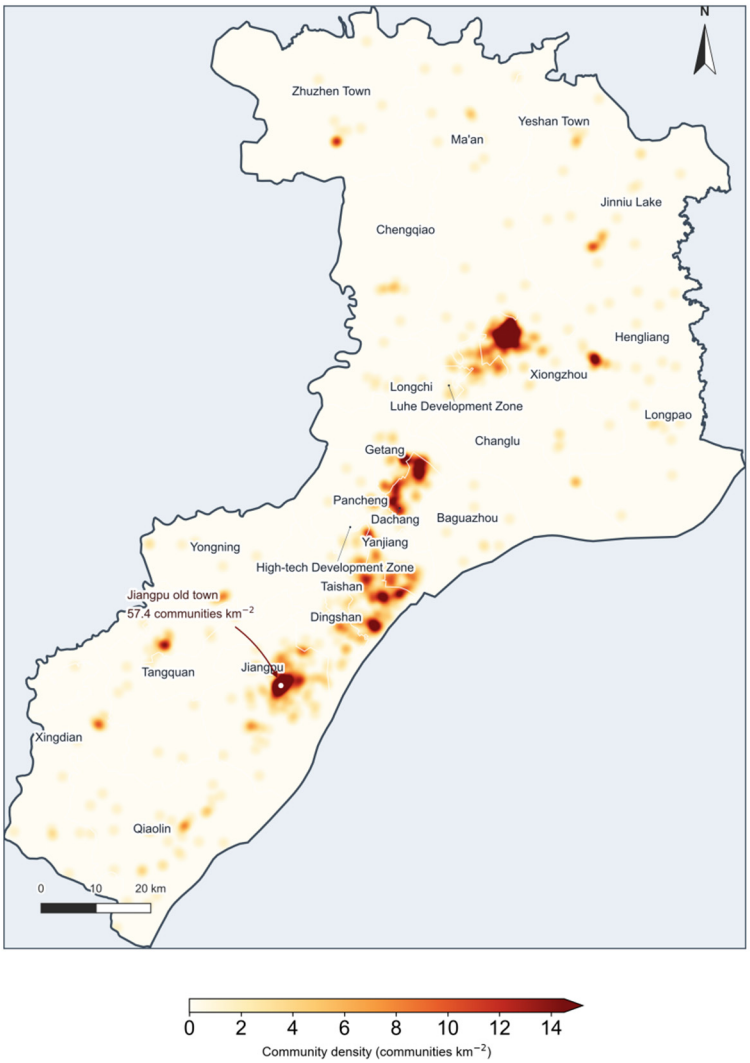


Figure 3. Kernel density of surveyed residential communities (quartic kernel, 800 m bandwidth, 50 m cell). The colour scale is capped at the 98th percentile, 14.5 per km^2, and the annotated peak reaches 57.4; the four administrative units without surveyed communities are left unlabelled.

Combining the standards with the collected POI data delimits the service scope of supporting facilities. For each of the 23 threshold indicators, the facilities were buffered by the normative radius and the 1169 residential units inside the township polygons were tested for inclusion; for the seven configuration-based indicators, the life circle was drawn around each unit. The service scope follows the community layout and mirrors the pattern of urban development: provision is dense in the southeast and sparse in the northwest, reflecting disparities in urbanisation, as the distribution of kindergartens in Figure 4 illustrates for a single indicator. Spatial join and aggregation in ArcGIS gave the number of communities covered by each facility's service area, and the coverage ratio is that number divided by the total. The ratio is the main measure of residential liveability, with a higher value signifying a more favourable living environment. Two adjustments apply.

Urban squares are assessed jointly with park green space under a common 500 m radius, and coverage within the two combined categories (supermarkets and convenience stores; waste collection points and stations) is computed with the larger of the two prescribed radii, so the reported ratios are conservative in these cases.

Table 4. Standards and specifications applied in the liveability assessment.

Standard and Specification	Code or Number
Standard for Urban Drainage Engineering Planning	GB 50318-2017
Standard for Urban Environmental Sanitation Facilities	GB-T 50337-2018
Standard for Construction of Emergency Shelters in Urban Communities	GB 180-2017
Standard for Planning and Design of Urban Residential Areas	GB 50180-2018
Standard for Landscaping Engineering Projects	GB 55014-2021
Code for Urban Green Space Planning	GB/T 51346-2019
Design Standard for Primary and Secondary Schools	GB 50099-2011
Standard for Urban Comprehensive Transportation System Planning	GB/T 51328-2018
Standard for Urban Parking Planning	GB/T 51149-2016
Code for Planning of City and Town Facilities for the Aged	GB 50437-2007
Code for Design of Disasters Mitigation Emergency Congregate Shelter	GB 51143-2015
Code for Planning of Urban Fire Control	GB 51080-2015

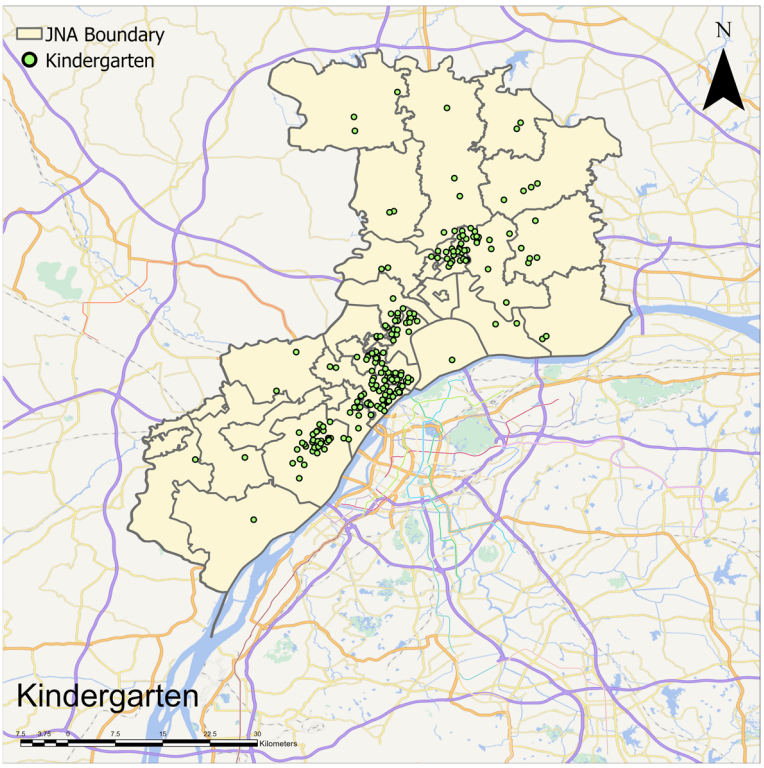


Figure 4. Distribution of kindergartens in the JNA.

For each indicator with a normative radius, buffer analysis delineates circular catchments around the facilities; for the seven configuration-based indicators, the life circle is drawn around each unit. Applying the same rule to all 30 makes their coverage comparable and allows the profile to be read from a single chart, which identifies which services are relatively well developed. As Figure 5 shows, the best-covered functions are bank outlets (76.6%), catering outlets (65.7%), postal outlets (60.5%), junior secondary schools (55.6%), farmers' markets (51.6%), general hospitals (50.1%) and clinics and outpatient departments (49.4%), followed by elderly care institutions (46.6%), supermarkets and convenience stores

(43.5%), public toilets (43.1%), pharmacies (43.0%), parks and green spaces (36.7%), kindergartens (36.4%), urban squares (35.8%), retail shops (35.2%), primary schools (34.5%) and recycling stations (34.3%).

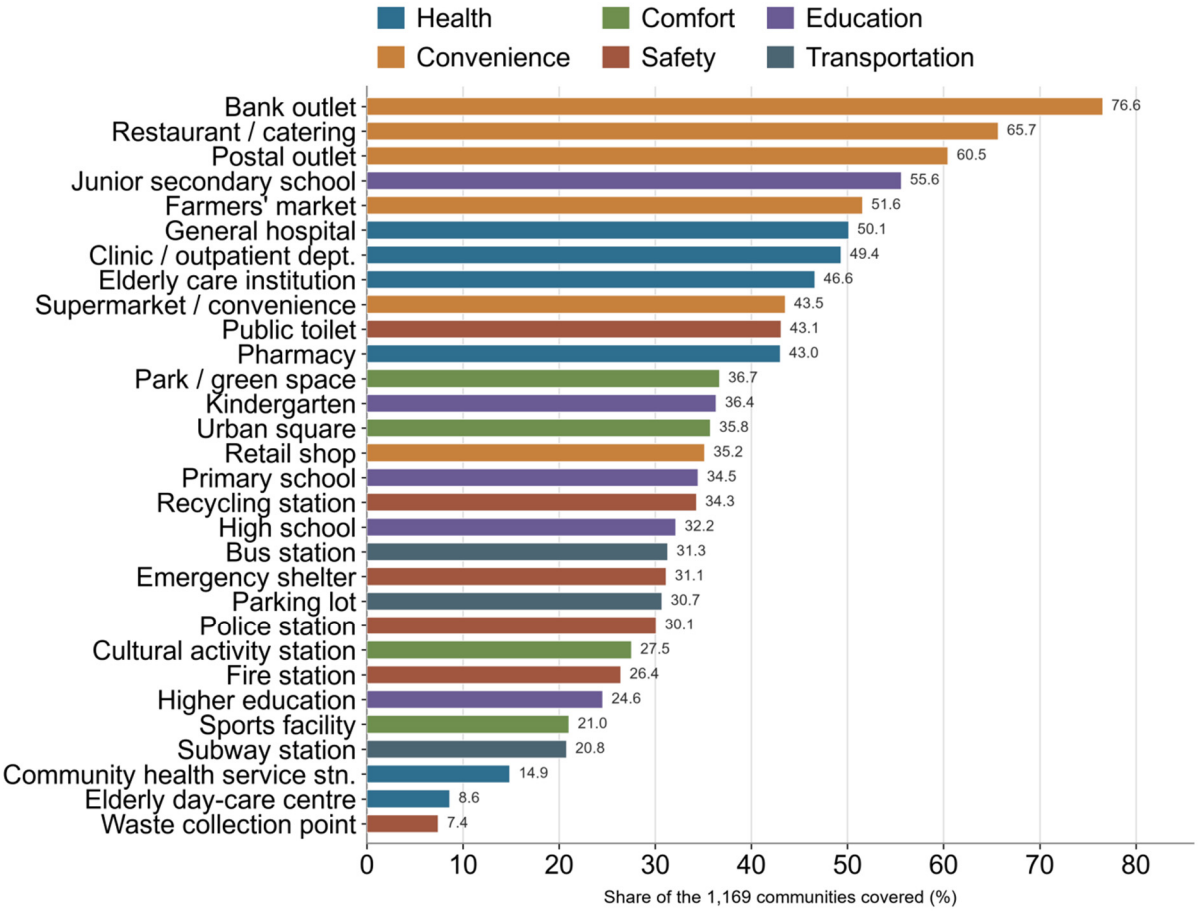


Figure 5. Coverage of ancillary service facilities: share of the 1169 communities with a facility of each class inside its normative radius or life circle. Colours denote the six liveability dimensions.

At the other end, waste collection facilities (7.4%), community day-care centres for the elderly (8.6%), community health service stations (14.9%) and subway stations (20.8%) show the most pronounced deficits, followed by sports facilities (21.0%), higher education institutions (24.6%), fire stations (26.4%), cultural activity stations (27.5%), police stations (30.1%) and parking lots (30.7%). These ratios leave considerable room for improvement in the layout of the corresponding functions, but they carry a spatial bias in data completeness: facilities in rural townships are less often registered on commercial platforms, so those ratios are lower bounds and part of the urban–rural difference may reflect registration rather than provision. They should not be read as absolute determinants of construction either. In GB 50180-2018, the CLC radius defines the residential area within which residents' material, social and cultural needs are met, and because the provision is advisory rather than mandatory, practice does not adhere to it strictly and longer commuting distances are generally permissible. The strategic focus should therefore be on the weakest links (the services with the most deficient coverage) where improvement most affects daily convenience. Figure 6 maps the facilities behind these indicators.

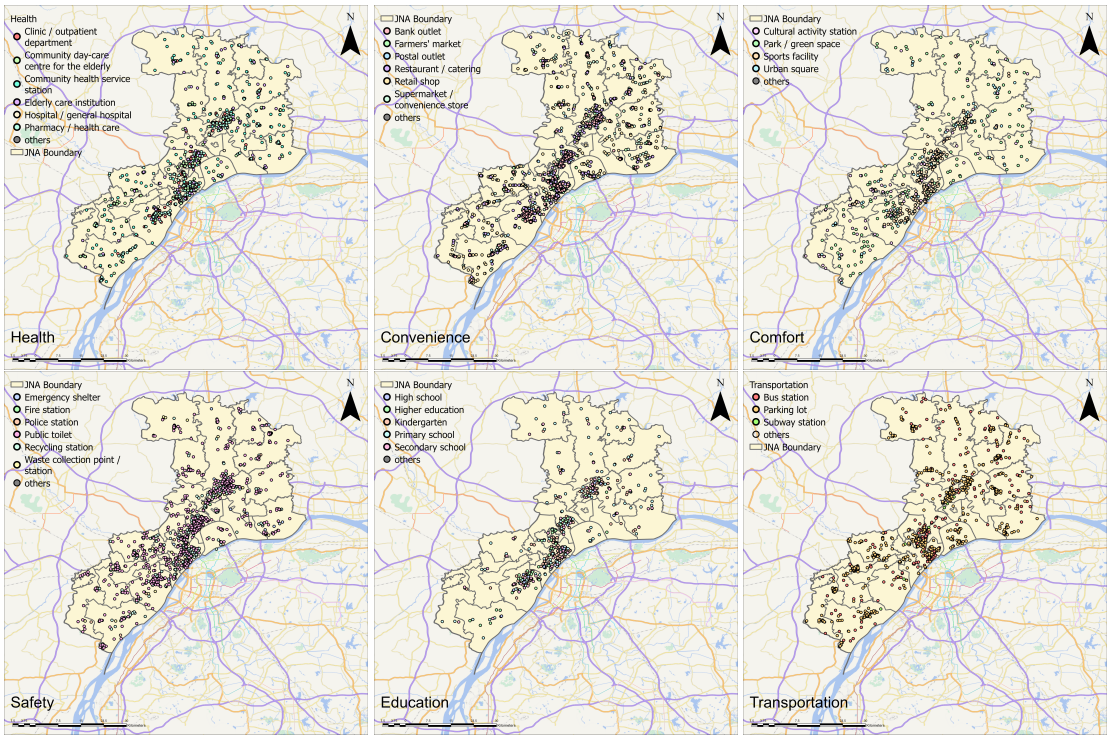


Figure 6. Visualisation of different liveable indicators.

3.2. Construction of Liveability Evaluation Index System

To assess liveability quantitatively, the 30 indicators of Table 3 were combined into a composite index. Throughout, liveability is shorthand for service-coverage-based liveability (the availability of a service within its normative radius or life circle), which is best described as potential provision rather than residents' realised experience, service quality or quality of life. For the 23 threshold indicators, coverage runs from facility to unit; for the seven configuration-based indicators, it runs from unit to facility. In both cases, an indicator contributes one point when the service is reachable within its threshold and zero otherwise, so a unit is credited with the availability of a service, not with the number of facilities that provide it. The two partial scores are:

$$S_f(c) = i = 1\sum_{22} I\left(min_{p \in P_i} d(c,p) \leq r_i\right) \quad (1)$$

$$S_r(c) = j = 1\sum_{6} I(min_{q \in Q_j} d(c,q) \leq R_j) \quad (2)$$

where c denotes a residential unit; P_i is the set of facilities belonging to the i-th threshold indicator and r_i the corresponding normative service radius; Q_j is the set of facilities belonging to the j-th configuration-based indicator and R_j the radius of the life-circle tier at which that item is required; $d(\cdot,\cdot)$ is the great-circle distance between a residential unit and a facility, computed with the Haversine formula; and $I(\cdot)$ is the indicator function, equal to 1 when its argument is true and 0 otherwise. $S^f(c)$ in Equation (1) therefore counts the services that reach the unit, whereas $S_r(c)$ in Equation (2) counts the services that the unit can reach. The composite liveability score of a residential unit is their sum:

$$S_c = S_f(c) + S_r(c) \quad (3)$$

An equal-weighting scheme was adopted: each indicator contributes one point. This is a methodological assumption rather than a neutral choice: it treats access to a hospital, a parking facility, a pharmacy, a sports facility and a postal outlet as equally important.

Equal weights were preferred because every indicator is expressed on the same bounded scale as a measure of provision, so none is systematically over- or under-represented, and because they avoid expert-derived weights that could not be validated within a single case study. No rescaling is applied: the score is simply the number of the 30 indicators a unit satisfies, and ranges from 0 to 30. Equal weighting also keeps the score additive and auditable, since each point traces back to one indicator and one facility layer. Because the weights are an assumption rather than a measured property, their influence is tested at the end of this section.

To evaluate liveability at township scale, the 1169 units were spatially joined to the administrative polygons in ArcGIS Pro (V3.0.36056), with each community being assigned to the unit containing its coordinates. Three polygons that carry an administrative code are not subdistricts or towns: Laoshan Forest Farm, Tangquan State Farm and the Zhenzhuquan Administrative Committee, which are a state forest farm, a state farm and the body managing a tourism resort, respectively. Together they account for only 0.19% of the population of Pukou District, and their land is predominantly forest, farmland and scenic area. Because a township comparison presupposes a residential population, they are excluded, and the six mapped communities assigned to them by the join were reassigned to the subdistricts in which their street addresses lie; the comparison therefore rests on 24 subdistricts and towns. For townships with several communities, the arithmetic mean of community scores represents the unit:

$$L_t = \frac{1}{m_t} \sum_{c \in t} S_c \tag{4}$$

where L_t is the aggregated index of township t and m_t its number of communities. Because the community score is bounded by 30, L_t is on the same scale and reads directly as the average number of the 30 services available to the mapped units of that township; scores are listed in Table 5 and mapped in Figure 7. Computed from the mapped units alone, the index describes those units rather than the resident population, and becomes statistically robust only where enough units are mapped; a household-weighted variant, which moves the measure towards the population, is therefore tested below (Table 6).

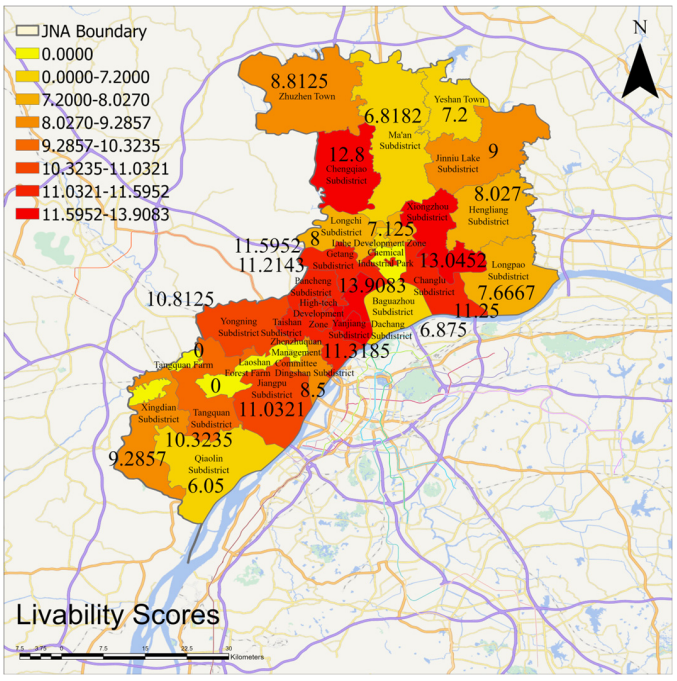


Figure 7. Township-level liveability scores in the JNA, classified by Jenks natural breaks.

Table 5. Liveability scores of towns, townships, and subdistricts in the JNA.

No	Name	Communities (m)	Σ S_c	L_township
1	Dachang Subdistrict	120	1669	13.91
2	Xiongzhou Subdistrict	199	2596	13.05
3	Yanjiang Subdistrict	69	896	12.99
4	Chengqiao Subdistrict	10	128	12.80
5	Getang Subdistrict	42	487	11.60
6	High-Tech Development Zone	19	216	11.37
7	Taishan Subdistrict	135	1528	11.32
8	Changlu Subdistrict	4	45	11.25
9	Pancheng Subdistrict	14	157	11.21
10	Jiangpu Subdistrict	218	2405	11.03
11	Yongning Subdistrict	16	173	10.81
12	Tangquan Subdistrict	34	351	10.32
13	Xingdian Subdistrict	21	195	9.29
14	Jinniuhu Subdistrict	25	225	9.00
15	Zhuzhen Town	16	141	8.81
16	Dingshan Subdistrict	44	374	8.50
17	Hengliang Subdistrict	37	297	8.03
18	Longchi Subdistrict	49	392	8.00
19	Longpao Subdistrict	9	69	7.67
20	Yeshan Town	10	72	7.20
21	Liuhe Development Zone	8	57	7.13
22	Baguazhou Subdistrict	8	55	6.88
23	Ma'an Subdistrict	22	150	6.82
24	Qiaolin Subdistrict	40	242	6.05

Note: m is the number of mapped residential communities in the unit and ΣSc the sum of their composite scores, with Lt = ΣSc/m. Units with fewer than ten mapped communities—Changlu Subdistrict (m = 4), Longpao Subdistrict (m = 9), Baguazhou Subdistrict (m = 8) and Luhe Development Zone (m = 8)—are reported for completeness but are not statistically representative.

Table 6. Sensitivity of the composite liveability ranking to alternative weighting schemes, to the aggregation rule and to the exclusion of the two non-normative education indicators.

Weighting Scheme/Indicator Set	ρ (Township Level)	ρ (Community Level)
Equal weights, 30 indicators (baseline)	1.000	1.000
Entropy weights (EWM), 30 indicators	0.956	0.974
Grouped equal weights (23 threshold/7 life-circle)	0.969	0.951
Monte-Carlo perturbation (σ = 0.35), median	0.979	—
Monte-Carlo perturbation (σ = 0.35), 5th percentile	0.956	—
Random Dirichlet(1) weights, median	0.922	—
Random Dirichlet(1) weights, 5th percentile	0.792	—
Household-weighted aggregation (logarithmic), 30 indicators	0.987	—
Household-weighted aggregation (square root), 30 indicators	0.960	—
Household-weighted aggregation (linear), 30 indicators	0.871	—
Equal weights, 29 indicators (higher education removed)	0.978	—
Equal weights, 28 indicators (higher education and high schools removed)	0.970	—

Jenks natural breaks were used to visualise the township scores, minimising within-class variance and maximising between-class variance; the result is mapped in Figure 7.

Table 6 reports how the ranking responds to alternative weighting schemes and to the exclusion of the two indicators that are not normative controls. Four alternatives were tested: entropy weighting (EWM), with weights proportional to the dispersion of each indicator's coverage; grouped equal weighting, giving the 23 threshold and the seven

life-circle indicators half of the total weight each; Monte-Carlo perturbation, multiplying every weight by an independent log-normal factor ($\sigma = 0.35$, 1000 draws); and fully random Dirichlet(1) weights (1000 draws). Agreement with the equal-weight ranking is expressed as Spearman's ρ. At township level, the entropy-weighted ranking correlates with the baseline at $\rho = 0.956$, the grouped scheme at 0.969, the median Monte-Carlo perturbation at 0.979 (5th percentile 0.956) and the median random scheme at 0.922 (5th percentile 0.792); at community level, the entropy-weighted ranking correlates at 0.974 and the grouped scheme at 0.951. Dachang, Xiongzhou, Yanjiang and Chengqiao stay among the five leading townships in at least 98% of the perturbed draws, and Qiaolin and Ma'an among the five trailing ones in every draw, so the spatial pattern does not depend materially on the weights. Entropy weighting shifts weight to the most unequally distributed indicators—waste collection (2.341) and community day-care centres for the elderly (2.207) rise, bank outlets (0.241) and catering outlets (0.379) fall—which is where the schemes diverge most, yet the correlation stays high because the re-weighted indicators are themselves strongly clustered in space. High schools and higher education institutions are inclusions rather than normative controls, and their influence was tested in the same way: removing higher education leaves the ranking almost unchanged ($\rho = 0.978$), and removing both still leaves it closely related to the full ranking ($\rho = 0.970$); the five lowest-ranked townships are unchanged, the leading group changes by one member, and the largest movement is four places. Neither the composite score nor its spatial pattern is therefore an artefact of the weights or of the two researcher-defined indicators; how the communities are aggregated is addressed below.

Aggregation weighting was tested in the same way. Each community was weighted by its recorded number of households, available for 1078 of the 1169 units and imputed at the township median for the remaining 91. Because the distribution is strongly skewed (median 552, maximum 15,524 households), three specifications were compared: linear, square-root and logarithmic. The extremes do not depend on the choice (Dachang remains first and Qiaolin last under all three) and the urban–rural contrast persists, with the subdistricts averaging 1.23 points above the non-subdistrict units against 1.40 under equal weighting. The middle of the ranking does: agreement with the baseline is $\rho = 0.987$ under logarithmic and 0.960 under square-root weighting, but falls to 0.871 under linear weighting, where Hengliang moves from 17th to 6th and Jiangpu from 10th to 16th. The district mean falls from 11.05 to 10.50, indicating that the average household lives in a somewhat less-served unit than the average mapped unit. Because the equal-weight unit mean describes the mapped stock rather than residents, it is retained as the primary measure, and the household-weighted results are reported as a bound on how far the ranking depends on the aggregation rule.

The geometric measure was validated in the same way. For 96 communities (four per township, one from each quartile of the within-township score distribution) the nearest facility of ten representative classes, covering all six dimensions, was routed along the pedestrian network with the Amap route-planning service, giving 960 origin–destination pairs; 71 pairs separated by less than 100 m are set aside from the ratio statistics, where the ratio is ill-defined, leaving 889. The pedestrian route is longer than the straight line almost everywhere: the median ratio of network to Euclidean distance is 1.38, with an interquartile range of 1.22–1.62. The inflation is close to uniform: the median is 1.38 in the subdistricts and 1.36 in the non-subdistrict units, and the two distributions do not differ significantly (Mann–Whitney $p = 0.78$). What the network changes is the level rather than the pattern. Of the pairs the Euclidean rule counts as lying within the normative radius, 42.8% fall outside it once the route is measured along the network (Table 7), and applying the median detour factor to all 30 indicators lowers every composite score by about 30%. The township

ranking remains closely related to the uncorrected one (ρ = 0.891), although individual positions move—Chengqiao rises from fourth to first—and the subdistrict–township gap narrows only slightly. The measure therefore does not favour one part of the study area over another, but it overstates the level of provision relative to walking distance: the thresholds are regulatory catchments applied geometrically, and the ratios should be read in that sense rather than as the share of residents who can walk to a service.

Table 7. Pedestrian-network validation of the Euclidean distance measure (96 communities, 960 origin–destination pairs).

Indicator Class	Median Network/Euclid Ratio	Within the Radius, but Beyond it on the Network
Park/green space	1.53	12 of 20 (60.0%)
Primary school	1.44	19 of 29 (65.5%)
Supermarket/convenience store	1.40	17 of 34 (50.0%)
Kindergarten	1.40	11 of 23 (47.8%)
Bus station	1.37	9 of 18 (50.0%)
Pharmacy/health care	1.36	14 of 25 (56.0%)
Bank outlet	1.36	10 of 58 (17.2%)
Hospital/general hospital	1.34	13 of 31 (41.9%)
Police station	1.33	8 of 36 (22.2%)
Subway station	1.29	8 of 9 (88.9%)
All ten classes	1.38	121 of 283 (42.8%)

3.3. Green Construction Indicators and Demonstration Projects

Section 3.1 assessed the macroscopic liveability of the urban environment; this section turns to the built environment. Green construction is the physical carrier of the development strategies named in the title: by improving indoor environmental quality and energy efficiency, it contributes directly to the Health and Comfort dimensions. The section covers the rating indicators (Section 3.3.1) and the projects that apply them (Section 3.3.2); the projects are contextual evidence for feasibility rather than a formal validation.

Green construction in the JNA rests on three coordinated layers: policies and green planning, green building projects, and green infrastructure. Green planning (green urban design, specialised planning for green buildings, energy, comprehensive water use and green transport) appears in planning documents that guide the construction of the JNA rather than in completed works. Green building projects concern individual buildings, with each applying one or more technologies such as water and energy conservation, prefabrication, photovoltaics and carbon reduction. Green infrastructure combines schemes with built works (underground space, ecological restoration, and waste recycling and classification in the core area), with each corresponding to one or more engineering projects.

3.3.1. Green Building Indicators

Green buildings are rated on a four-level scale: basic level, one-star, two-star and three-star. Evaluation begins with a pre-evaluation score against seven control-item categories, each with a fixed maximum contribution (Table 8); the final total score Q is obtained by summing the weighted category scores.

$$Q = (Q_0 + Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_A)/10$$

The mandatory evaluation requirements are listed in Table 9. A building meeting the requirements of both Tables 8 and 9 is classified as a basic-level green building, and those additionally reaching total scores of 60, 70 or 80 points are rated one-, two- or three-star, respectively.

Table 8. Green building evaluation score.

	Basic Score of Control Items (Q_0)	Safety and Durability (Q_1)	Health and Comfort (Q_2)	Life Convenience (Q_3)	Resource Conservation (Q_4)	Inhabitable Environment Quality (Q_5)	Improvement and Innovation (Q_A)
Pre-evaluation score	400	100	100	70	200	100	100
Evaluation score	400	100	100	100	200	100	100

Table 9. Green Building Evaluation Standard.

Evaluation Item	One-Star	Two-Star	Three-Star
The proportion of improvement in thermal performance of enclosure structures or the proportion of reduction in heating and air-conditioning compliance in buildings	5%	10%	20%
The proportion of reduction in heat transfer coefficient of exterior windows of residential buildings in severe cold and cold regions	5%	10%	20%
Water efficiency level of water-saving appliances	Level 3	Level 2	
Sound insulation performance of residential buildings		The air sound insulation performance between the outdoors and the bedroom, as well as the impact sound insulation performance between the bedrooms on both sides of the partition wall (floor slab), reach the average of the low-limit standard limit and the high-limit standard limit for the bedroom floor slab	
The proportion of reduction in the concentration of major indoor air pollutants	10%	20%	
External window airtightness performance	Complies with the current national energy-saving design standards, and the joint between the exterior window opening and the exterior window body should be tight	External window airtightness performance	

3.3.2. Green Demonstration Projects

Two categories of demonstration project have been delivered in the core area. The first comprises 25 certified green building projects with a total floor area of 3.1571 million m^2, including nine three-star projects totalling 787,900 m^2 (24.96%), assessed against the Green Building Evaluation Standard of the Ministry of Housing and Urban-Rural Development, which defines a green building as one that saves resources, protects the environment, reduces pollution and provides healthy, efficient space over its life cycle. The second comprises green municipal facilities themed around sharing and environmental friendliness, in four groups: comprehensive urban space development, district energy utilisation, urban

lifeline, and comprehensive renovation. Representative projects are listed in Table 10, and Figure 8 shows a selection of the green buildings.

Table 10. Green building and municipal facility demonstration projects.

Category	No.	Project Name	Period	Land Area (m^2)	Total Building Area (m^2)	Rating/ Objective
Green building	1	Jiangbei International Campus of Nanjing Gulou Hospital	2019	143,000	394,000	Three-star
	2	JNA Citizen Center	2020	55,000	75,000	Three-star
	3	Nanjing No. 1 Middle School, Jiangbei Campus (Senior High Section)	2020	100,000	108,000	Two-star
	4	Nanjing JNA Service Trade Innovation and Development Building	2020	20,000	83,000	Three-star
	5	Nanjing Yangzi River International Convention Center	2021	87,000	187,000	Three-star
	6	Nanjing JNA Talent Apartment, Building 3	2021	69,000	230,000	Three-star
	7	Nanjing JNA Talent Apartment (Parcel 1) Project Community Center	2021	2768	2376	Three-star
	8	Jiangbei Library	2022	19,000	80,000	Three-star
	9	New Nanjing Art Museum	2022	35,300	97,300	Three-star
Green municipal facility	1	Phase I of the Underground Space Complex in the Central District of JNA	2017–2023	—	—	Comprehensive urban space development
	2	The River Water Source Heat Pump District Heating and Cooling System in the Central District of JNA	2018–2030	—	—	District energy utilisation
	3	Phase II of the Utility Tunnel Network in JNA	2017–2021	—	—	Urban lifeline engineering
	4	The Qinglong Greenway Project in JNA	2018–2019	—	—	Comprehensive improvement of human settlements
	5	Dingshan Urban Living Room	2019–2021	—	—	Yangtze River shoreline restoration
	6	The Construction and Demolition Waste Resource Recovery Project in JNA	2023–2025	—	—	Waste resource recovery and disposal

The representative municipal projects share a few technical features. The Phase I Underground Space Complex in the Central District improves land utilisation through comprehensive use of underground space, elevated-corridor connections and an integrated rail–bus–pedestrian transfer system; its excavation reaches about 48 m over seven levels, supported by 53.38 m steel pipe columns weighing about 32.07 t each. The River Water

Source Heat Pump system uses Yangtze water as a heat source and sink, exchanging heat with the buildings' internal circulation to provide district heating and cooling. Phase II of the Utility Tunnel Network comprises 241 km of underground galleries, 60 km of which are in the core area, relocating power, communication, water and gas facilities underground for centralised management. The Qinglong Green Belt builds parks on hilly and valley terrain, turning former industrial waterfront into public leisure space.



Figure 8. Partial green building demonstration projects.

4. Discussion

This section develops a framework that combines an area-wide assessment of liveability with an examination of the JNA's construction achievements, and discusses the challenges, the relations among the framework's elements and the classification of the technologies deployed. It is organised around two evidence bases at different scales: the area-wide assessment of Section 3.1 and the demonstration evidence of Sections 3.3 and 4.3, drawn from spatially agglomerated projects. Keeping the two separate is essential; transferability is discussed in Section 4.4. The framework is a conceptual integration rather than a validated analytical model: its contribution lies in combining established components (life-circle accessibility, area-wide POI assessment and demonstration-project evidence) into a decision-support logic system, validated in direction rather than in magnitude.

4.1. The Guiding Significance of Liveability Indicators and Urban Facilities

Liveability indicators serve both as retrospective evaluation tools and as prospective guides to facility configuration. By combining Maslow's hierarchy with the quantitative constraints of GB 50180-2018, the study links abstract goals to concrete spatial layouts. The assessment shows that the JNA performs comparatively well in daily-need and basic services (bank outlets reach 76.6% of units, catering outlets 65.7%, postal outlets 60.5% and junior secondary schools 55.6%), whereas network-based and specialised functions remain weakly covered: waste collection reaches 7.4% of units, community day-care centres for the elderly 8.6%, community health service stations 14.9% and subway stations 20.8%. Provision has expanded faster in static, building-based amenities than in the network-based services that determine the effective reach of a life circle.

These indicators also identify blind spots. The observed heterogeneity—southeastern urbanised areas with superior access, the northwestern hinterland without—calls for a shift from extensive expansion to precision supplementation, redirecting resources to the weakest functions of Section 3.1 (waste collection, day-care centres for the elderly, community health stations and subway stations) and to the underserved townships of the northwest and northeast.

4.2. The Urban–Rural Gradient in Residential Distribution

The density surface of Figure 3 shows a systematic association between the distribution of communities, together with their supporting facilities, and downtown Nanjing. Density declines monotonically with distance from downtown, which is physically connected to the JNA by the Nanjing Yangtze River Bridge and the Yangtze River Tunnel; streets adjacent to these links therefore show markedly higher accessibility, a pattern consistent with stronger urbanisation and connectivity near the existing centre rather than with a directional transfer of construction resources. The gradient is measured by service coverage alone, so it reflects both lower provision and uneven POI registration; rural scores should be read as a lower bound and the urban–rural difference as an upper bound on the true difference.

Towns and villages not connected to the upgraded street network remain in a pre-urbanisation state, with low-density multi-storey self-built housing and none of the agglomeration effects of formal communities, and with minimal real-estate development. With the national slowdown of the real-estate market, this fragmented pattern goes with a slow urbanisation of the peripheral towns and villages. Bridging the gap requires a strategy along four dimensions: industrial development, transport guidance, urban–rural integration and service equity.

(1) Industrial development

To avoid homogenised competition with the main urban area, the JNA should differentiate its economic profile, using its spatial advantages to prioritise strategic emerging industries such as biomedicine, life sciences and health, and artificial intelligence, alongside high-value services including modern logistics and R&D. Specialised parks, exemplified by the Nanjing JNA Research and Creation Park, serve as platforms for attracting leading enterprises and high-end talent and for generating employment.

In the township regions, the emphasis should shift to endogenous development, cultivating industries rooted in local characteristics (modern agriculture, rural tourism and green food processing) to stimulate local economic vitality, achieve sustainable local urbanisation and reduce dependence on the core.

(2) Transportation guidance

Beyond the existing crossings, new Yangtze links should be planned with a focus on the northwestern part of the district, where transport provision is weakest, so as to improve the connectivity of the regional road network. Transit efficiency should be raised by integrating bus routes with the metro system and promoting transfers among metro, bus and shared bicycles, while feasibility studies on extending selected regional lines into the JNA hinterland would strengthen integration with the wider metropolitan region.

(3) Urban–rural integration

Urban–rural integration is the main lever on the traditional dual structure. It can be pursued through land development models that prioritise ecological protection while optimising land-use patterns, allocating land first to key agricultural projects and infrastructure so that the potential of rural land is activated. Administrative decentralisation complements this: relocating selected municipal agencies or service centres to the JNA would strengthen the new area's public service capacity and extend its regional influence.

(4) Service equity

Raising the liveability of the JNA requires public services competitive with those of the main urban area in order to attract and retain talent. This involves introducing high-quality educational resources such as branch campuses of prestigious city schools; developing advanced medical facilities, including comprehensive and specialised hospitals, with a

stronger network of community health service centres; and providing commercial and cultural amenities such as libraries, museums and sports venues.

4.3. Coordination Between Construction and Non-Construction Projects

Construction in the JNA has produced two kinds of outcomes: non-construction projects, comprising planning documents and guiding policies, and construction projects, comprising buildings and infrastructure. The two do not proceed in chronological order but in parallel, for three reasons.

(1) Lag in policy implementation

In China, policies may be national, local or regional. Local policies are formulated on the basis of national ones and take account of provincial conditions, but still require national review; before release, they go through several rounds of expert discussion and public consultation, which typically takes months or years.

(2) Diversification of project entities

Different entities are involved. Government-led projects are organised by the government and executed by design and construction units, follow higher standards, sometimes serve cultural promotion and industrial development as well as daily functions, and are subject to strict construction periods. Other projects are undertaken by companies or individuals who buy land with government permits and proceed with self-design and construction; these meet owners' specific needs and are not subject to detailed period control.

(3) Differences between infrastructure projects and conventional construction projects

Compared with conventional projects, infrastructure projects have longer construction periods, larger scales and greater difficulty in site management. The underground phase-one project, for example, involves the handling of underground space and the comprehensive construction of vertical space, while the waste recycling and utilisation project requires the rational allocation of treatment equipment across several locations. The southeastern part of the JNA lies along the Yangtze and contains extensive waterfront and wetland; the approach adopted combines flood control, ecological protection and restoration with public demand for activity space and green landscape.

4.4. Spatial Agglomeration of Demonstration Projects and the Transferability of Evidence

The assessment and the demonstration evidence rest on different spatial bases, and the relationship must be made explicit. The diagnosis of Section 3.1 derives from a POI database covering the entire JNA (the whole of Pukou and Liuhe Districts together with Baguazhou Subdistrict of Qixia District) and from 1169 residential units spread across both the urbanised subdistricts along the Yangtze and the rural townships of the northwest and northeast. The coverage ratios, township scores and identification of blind spots therefore rest on area-wide evidence and do not depend on the core area.

The demonstration projects examined in Sections 3.3 and 4.3, by contrast, occupy few locations. The concentration is agglomeration rather than a sampling defect. Demonstration projects of any kind tend to cluster: they share infrastructure and supply chains, compete for the same skilled labour, depend on the same policy platforms and financial instruments, and learn from proximity. Clustered demonstration activity is a general regularity of industrial and urban development. In the JNA, this cluster coincides with the designated core area, so the CAJNA boundary labels where the projects happen to be concentrated rather than causing that concentration; without the designation, the projects would still be expected to locate close together, drawing on the same cross-river links, the same utility and transport corridors, and the same pool of design and construction capacity. The demonstration evidence is accordingly used to establish what is technologically and

institutionally feasible under the current planning regime, not to estimate the average construction level of the JNA.

Transferring this evidence to the rest of the new area is subject to three conditions. First, it concerns the technical and normative dimension (the choice of passive and active energy-saving measures, water and photovoltaic systems and carbon-reduction strategies) rather than quantitative liveability outcomes. Second, the receiving areas must operate under the same regulatory framework of national design standards, green building evaluation standard and provincial implementation rules. Third, they must have reached a comparable stage of infrastructure provision, because the incremental value of a technology depends on the baseline already achieved.

Read this way, the agglomeration delimits the scope of the technological claims without weakening the diagnosis. The clustered projects make visible, at full scale, the construction pathways that the area-wide analysis identifies as binding constraints, and they supply the empirical anchors for the "optimised evaluation" step; reciprocally, the assessment indicates where the demonstration experience is most needed and which deficits later stages of construction must close. The two evidence bases are complementary rather than substitutable, and the rural townships are not excluded from the framework: because demonstration activity agglomerates, closing their deficits is a matter of sequencing rather than of sampling.

5. Limitations and Future Work

5.1. Limitations

Five limitations bound the claims. First, the demonstration projects are spatially agglomerated, as demonstration activity generally is; the evidence therefore establishes the technical and institutional feasibility of the proposed measures, not the average construction level of the JNA, and transfer elsewhere is subject to the conditions of Section 4.4. Second, although the POI database covers the whole JNA, its completeness is uneven, because automated collection under-represents rural townships, where facilities are less often registered on commercial platforms; the coverage ratios of Section 3.1 are relative measures and should be read as a lower bound for those townships. Third, the quantitative link between green construction and measured liveability remains unestablished, because the projects are recent and the score is a static, accessibility-based measure; the framework is a transferable decision-support logic system, validated in direction rather than in magnitude. Fourth, the scores measure potential geometric accessibility, not the accessibility residents experience. A unit is credited when a facility of the required type lies within the normative radius or the prescribed life circle, measured as a straight-line distance; road connectivity, physical barriers, facility capacity, service quality and population demand are not represented. The sample-based check of Section 3.2 shows that the pedestrian route is on average 38% longer than the straight line and that this error, close to uniform across subdistricts and townships, lowers the measured level of provision when the radii are read as walking distances; the scores therefore describe the spatial provision of services rather than realised access, and their level is not directly comparable with walking access. Fifth, the 30 indicators are weighted equally, which is an assumption rather than a neutral property of the indicator set: a hospital, a recycling station, a parking facility and a higher-education institution are treated as equally important. Equal weights were adopted for transparency and traceability; the ranking is robust to alternative indicator weights and, at its extremes and in its urban–rural contrast, to household-weighted aggregation (Section 3.2), although the middle of the distribution is sensitive to that choice, and the scores remain conditional on these assumptions.

5.2. Future Work

Future work will proceed along two tracks. The first extends the demonstration analysis outward: as the projects enter operation, we plan to collect post-occupancy data on their surrounding facilities and to develop a quantitative method linking green construction measures to liveability indicators, so that transfer to the suburban and rural townships can be assessed rather than assumed. The second concerns the rural townships, where automated mapping is insufficient because geocoded facility registrations are largely absent; a hybrid approach combining government collaboration, field survey and manual compilation is required. A further objective is to broaden the information base through departmental collaboration, to capture POI types such as logistical support facilities and civil air defence works and to complete the inventory of service facilities and municipal pipelines. A multi-case comparison with other national-level new areas will test how far the framework generalises, and will complement the lessons drawn from planned resettlement and new-town experience elsewhere [34]. Two extensions follow from the sensitivity checks. Household counts, which proxy community size, should give way to resident population once community-level registration data are released, since average household size differs between high-rise estates and the older low-rise stock. Pedestrian routing should likewise be extended from 96 communities to all 1169 units and all 30 indicators, so that network distance can replace the straight-line measure rather than benchmark it.

6. Conclusions

This study examined how liveability can be diagnosed and improved in a national-level new area, and proposes an integrated framework of "top-level design–liveability indicators–demonstration projects–optimised evaluation". The framework links normative goals to measurable spatial variables, tests them against demonstration practice and feeds the result back into planning; it was developed and applied to the Nanjing Jiangbei New Area.

Applied to the JNA, the analysis of 1169 residential units against 6711 facilities yields a clear diagnosis of spatial service accessibility. Market-provided daily services are comparatively well covered—bank outlets (76.6%), catering outlets (65.7%), postal outlets (60.5%) and junior secondary schools (55.6%)—whereas network-based and specialised functions lag: waste collection (7.4%), community day-care centres for the elderly (8.6%), community health service stations (14.9%) and subway stations (20.8%) are the most pronounced deficits. Provision declines markedly and monotonically from the southeastern subdistricts towards the northwestern and northeastern townships, so the urban–rural gap appears not as a single threshold but as a spatial gradient. Because facilities in rural townships are less often registered on commercial platforms, the rural ratios are lower bounds and this gradient is an upper bound on the true difference. Neither the ranking nor the gradient depends on the weighting of the indicators (Section 3.2), so the spatial pattern is a property of the data rather than of the weighting choice. Together, these results identify the constraints that any optimisation strategy must address.

The green construction evidence shows that these constraints can be addressed with technologies and institutions that are already available: certified green buildings, district energy systems based on river-water heat pumps, utility tunnels and ecological waterfront restoration demonstrate at full scale how indoor environmental quality, energy performance and municipal service capacity can be raised. The evidence comes from agglomerated projects and is not a proxy for the whole new area. It matters because demonstration activity clusters as a matter of regularity (projects share platforms, infrastructure and technical capacity), so demonstration sites sit close together whether or not a core area has been

designated. Transferring their experience outward is what the framework proposes, subject to the conditions set out in Section 4.4.

Two implications follow. For planning practice, the value of an indicator system lies less in ranking places than in sequencing interventions: it shows where a demonstration-led strategy should be pointed next and which deficits later stages of construction must close. For research, the framework should be tested against post-occupancy evidence and across comparable new areas, so that transfer of the agglomerated experience can be measured rather than assumed. The framework is a conceptual decision-support tool rather than an empirically validated causal model: the demonstration projects establish technical and institutional feasibility, but they do not show that construction measures caused the measured differences in service coverage. Read this way, the spatial concentration of demonstration investment is a property of how new area construction is organised rather than a limitation of the analysis, and the framework offers a transferable model for other NNAs facing the same combination of concentrated demonstration and dispersed rural need.

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Abbreviations

CAJNA	Core Area of Jiangbei New Area
CLC	Community life circle
JNA	Jiangbei New Area
NNA	National-level new area
NT	New town

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