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Dataset Development of the Spatial Distribution of 180 Earthquake Emergency Shelters in Beijing

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Abstract: Earthquake emergency shelters are a crucial component of the urban public safety and emergency management system. They are closely linked to national security and represent an integral part of comprehensive all-hazard emergency management. During major sudden events dominated by earthquake disasters, these evacuation sites play a critical role by providing early warning response, disaster relief, rescue operations, and temporary accommodation. Their functions help achieve the goals of safe evacuation, sheltering disaster victims, and maintaining social stability. Based on the statistical information of 180 earthquake emergency shelters released by the Beijing Emergency Management Bureau, this study utilizes the geocoding interface of internet map services to extract the geographic coordinates of each site and establish a spatial distribution dataset of earthquake emergency shelters in Beijing. The dataset includes information such as the name, type, address, XY coordinates, and total area of each site. It is archived in .shp and .xls formats, comprising 9 data files with a total data volume of 333 KB (compressed into 1 file of 47.9 KB).

Keywords: earthquake emergency shelter; comprehensive disaster prevention; spatial point; Beijing

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2025.08.04.V1.

1 Introduction

Urban land is fundamental to city development and serves as the essential basis for production and livelihoods in cities. With rapid population growth and increasing urban migration, challenges related to employment, housing, infrastructure, and environmental safety have become more pronounced. In this context, developing scientific and effective urban planning and land management strategies has become essential for achieving

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sustainable socio-economic development and advancing the construction of resilient cities[1]. Although urban areas occupy less than 1% of the world's land surface, they generate 75% of the global GDP and consume 60%–80% of global energy. Recognizing these dynamics, the United Nations released "Transforming our world: the 2030 agenda for sustainable development" in 2015, which outlines 17 sustainable development goals (SDGs) and 169 specific targets encompassing economic, social, and environmental dimensions. Among these, "Build resilient, inclusive, safe, and sustainable cities and human settlements" (SDG 11) is considered a key driver for achieving all other SDGs[2]. Rapid urbanization also poses significant challenges to urban disaster response capabilities, making the construction of sustainable and resilient cities and communities a vital area of research in disaster prevention and mitigation[3,4].

China's government has placed great emphasis on emergency management[5]. As the capital of China, Beijing holds significant domestic and international influence. Covering a total area of 16,410.54 km^2 and governing 16 districts, the city's permanent population reached 21.858 million in 2023, with an annual regional GDP of 4.376,07 trillion CNY, making it a representative megacity. Historically, the Beijing Region has experienced nearly 200 earthquakes of magnitude 4.0 or higher, including 1 reaching magnitude 8.0. In 2003, China's first emergency shelter was established at the Yuan Dadu City Wall Ruins Park in Beijing, fully demonstrating the city's exemplary role in emergency shelter construction. Given equivalent seismic impacts, Beijing's demand for emergency shelter resources is particularly pressing[6].

To promote the construction of resilient cities, the Beijing government issued the "Guidance on accelerating resilient city construction" in 2021. The document emphasizes that building resilient cities is essential for ensuring urban safety and sustainable development. It explicitly calls for systematic planning and the coordinated advancement of comprehensive emergency shelters, recognizing them as a core element of the public safety system. These shelters are indispensable for addressing all-hazard scenarios and play a key role in early warning, emergency response, rescue, and transitional resettlement. Therefore, their scientific and rational planning and construction are of utmost importance. Promoting resilient city construction is essential to meeting the disaster prevention needs of megacities and achieving high-quality, safe, and sustainable development.

Currently, Beijing has a total of 180 earthquake emergency shelters, classified into 3 categories based on their configuration standards and capacity. Type I shelters (14 in total) are fully equipped and can accommodate evacuees for more than 30 days. Type II shelters (77 in total) are standardly equipped and can provide accommodation for 10 to 30 days, while Type III shelters (89 in total) are minimally equipped and can accommodate evacuees for up to 10 days. These shelters encompass various types of facilities, including parks (excluding zoos and protected cultural heritage sites), green spaces, squares, stadiums, and other municipal public infrastructures.

As the economy and society continue to develop, ensuring a corresponding level of security has become a key objective in modern urban governance. Strengthening urban resilience, enhancing self-adaptive capacity, and improving risk prevention preparedness have given new significance to emergency shelter planning and management[7]. At the same time, societal demand for emergency shelter capacity continues to grow[8]. To address these needs, this dataset provides spatial point information for 180 earthquake emergency shelters in Beijing (2021–2025), including detailed data such as shelter categories, administrative divisions, and spatial scope definitions. The dataset offers essential support for studying the spatial distribution and service efficiency of Beijing's earthquake emergency shelters. Moreover, this dataset holds substantial value for optimizing the spatial layout of emergency shelters, promoting the integration of peacetime and disaster prevention measures within comprehensive urban disaster prevention systems, and advancing high-quality and safe urban development.

2 Metadata of the Dataset

The metadata of Spatial distribution dataset of 180 earthquake emergency shelters in Beijing[9] is summarized in Table 1. It includes the dataset full name, short name, authors, year of the dataset, data format, data size, data files, data publisher, etc.

Table 1 Metadata summary of the Spatial distribution dataset of 180 earthquake emergency shelters in Beijing

Items	Description
Dataset full name	Spatial distribution dataset of 180 earthquake emergency shelters in Beijing
Dataset short name	BeijingEES180
Authors	Cheng, L., School of Geography and Environmental Sciences, Northwest Normal University, colgate77@163.com Sheng, S. Q., School of Land Science and Technology, China Agricultural University, shengsq@cau.edu.cn Ma, Y., School of Geography and Environmental Sciences, Northwest Normal University, Myue_0321@163.com Zhang, X., School of Geography and Environmental Sciences, Northwest Normal University, Zhxuan9106@163.com
Geographical region	Beijing (16 districts)
Year	2021–2025
Data format	.shp, .xls
Data size	333 KB
Data files	Information on the name, scope or address, type, and total area of each shelter
Foundations	National Natural Science Foundation of China (42061054, 41561110)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the "ten percent principal" should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[10]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

3 Methods

3.1 Research Area

Beijing (115°25′00″E–117°30′00″E, 39°26′00″N–41°03′00″N) is located in the northern part of China, bordering Tianjin to the east and Hebei Province on all other sides. The city administers 16 districts with a total area of 16,410.54 km^2. The geographical center of the municipality is situated in Xingshou Town, Changping District, at approximately 40°15′02.1″N, 116°27′45.4″E. The topography of Beijing is characterized by distinctly higher elevations in the northwest and lower elevations in the southeast. The western, northern, and northeastern parts of the city are surrounded by mountains, while the southeastern area consists of a gently sloping plain that opens toward the Bohai Sea. Mountainous regions account for about 61% of the city's total area. This geographical configuration gives Beijing a typical warm temperate semi-humid continental monsoon climate, with 4 distinct seasons: cold, dry winters, hot, rainy summers, and short, transitional spring and autumn periods. The multi-year average annual rainfall is 585 mm. Major rivers within the municipality include the Yongding River, Chaobai River, Beiyun River, and Juma River, all of which play vital roles in Beijing's ecosystem and water resource management.

3.2 Methods

This study collected statistical information on earthquake emergency shelters in Beijing and compiled zonal statistics for all 16 districts. Using the geocoding interface of an internet map service, the administrative divisions and geographic coordinates of each earthquake emergency shelter were extracted, after which the longitude and latitude data were added to the original information table. With the support of ArcGIS 10.8, the spatial distribution of earthquake emergency shelters in Beijing was visualized, and their spatial distribution characteristics were analyzed in detail.

3.2.1 Data Sources

The statistical information on earthquake emergency shelters in Beijing was obtained from relevant notices issued by the Beijing Emergency Management Bureau[11]. These data include information such as the location, name, address, type, and total area of each shelter. The coordinate data for the shelters were collected through the address service of the Amap platform[12], and the precise coordinates were obtained using coordinate conversion tools.

3.2.2 Data Processing

(1) Coordinate acquisition

The statistical information table of earthquake emergency shelters published on the official website of the Beijing Emergency Management Bureau does not include geographic coordinates. Therefore, the Amap location service (Amap Address Service/Amap API)[12] was used to perform geocoding based on the names and addresses of each emergency shelter to obtain their coordinates. The GCJ-02 coordinate system used by Amap was then converted to the Krasovsky 1940 coordinate system using a coordinate conversion tool to ensure data accuracy and consistency.

(2) Supplementary zoning

Although the original statistical table of earthquake emergency shelters in Beijing included the addresses and administrative districts of each site, some information had become outdated due to the time span between releases and changes in administrative boundaries. To ensure data timeliness and accuracy, the latest administrative division information was retrieved using the Amap reverse geocoding interface, based on the updated location coordinates.

(3) Data storage

Based on the obtained geographic coordinates of earthquake emergency shelters in Beijing and the latest administrative division data, a spatial data file in .shp format was generated, while attribute information such as the name, address, and type of each shelter was archived synchronously in the .xls file to support further analysis. The names and examples of each field are provided in Table 2.

Table 2 Dataset attributes

Article	Description
Serial Number	1, 2, 3, …, 180
Region	Dongcheng District, Xicheng District, Changping District, …
Name	Huangchenggen Ruins Park, Longtan Park, Wanshou Park, …
Address	Located between Nanbei Heyan Street to the west and Chengguang Street to the east, …
Type	Ⅰ, Ⅱ, Ⅲ

4 Data Results

4.1 Dataset Composition

The Spatial distribution dataset of 180 earthquake emergency shelters in Beijing consists of 2 components: (1) vector data of emergency shelter locations (.shp), and (2) attribute data of the shelters, including name, address, type, total area, and administrative division (.xls).

4.2 Data Results

The 180 earthquake emergency shelters are distributed across all 16 districts of Beijing, with notable differences in shelter numbers among districts (Figure 1). Daxing District has the highest number, with 39 shelters, accounting for 21.7% of the city's total. This number not only far exceeds that of other districts but also surpasses the combined total of the 8 districts with the fewest shelters. The remaining distribution is as follows: 23 in Haidian District, 20 in Changping District, 18 in Chaoyang District, 14 in Fangshan District, 12 in Dongcheng District, 10 in Tongzhou District,10 in Xicheng District, 8 in Mentougou District, 5 in Shijingshan District, 5 in Pinggu District, 5 in Fengtai District, 4 in Yanqing District, 3 in Miyun District, 2 in Huairou District, and 2 in Shunyi District. This distribution pattern indicates that Beijing's emergency shelter planning carefully considers differences in population density and emergency needs across the city's various regions.

The distribution of earthquake emergency shelters in Beijing exhibits a clear clustering pattern in the central urban area (Figure 2). Overall, the high-density areas (with a maximum value of 0.216) for all three types of shelters are primarily concentrated in the southeastern part of Haidian District, the western part of Chaoyang District, Shijingshan District, Xicheng District, Dongcheng District, and the eastern part of Fengtai District. This distribution pattern demonstrates a pronounced concentration in the southern and central urban areas, with relatively sparse coverage toward the northern and outer suburban districts.

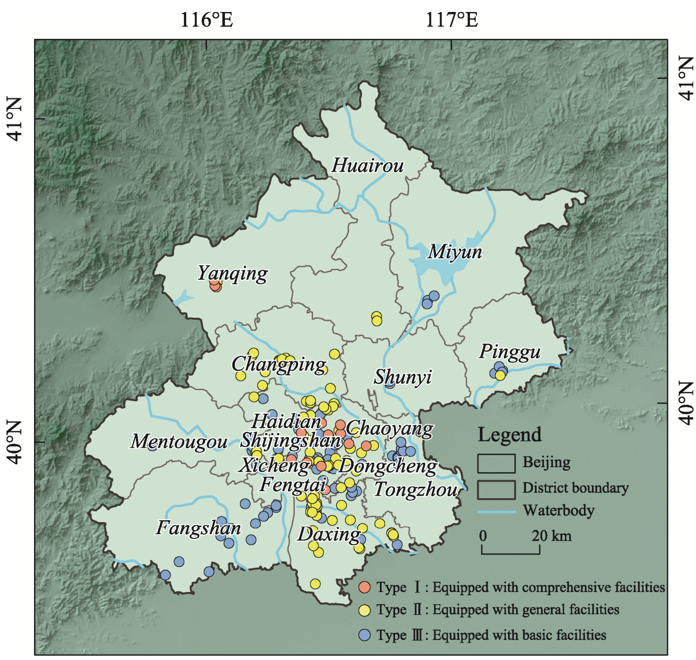

Figure 1 Spatial distribution map of the earthquake emergency shelters across Beijing

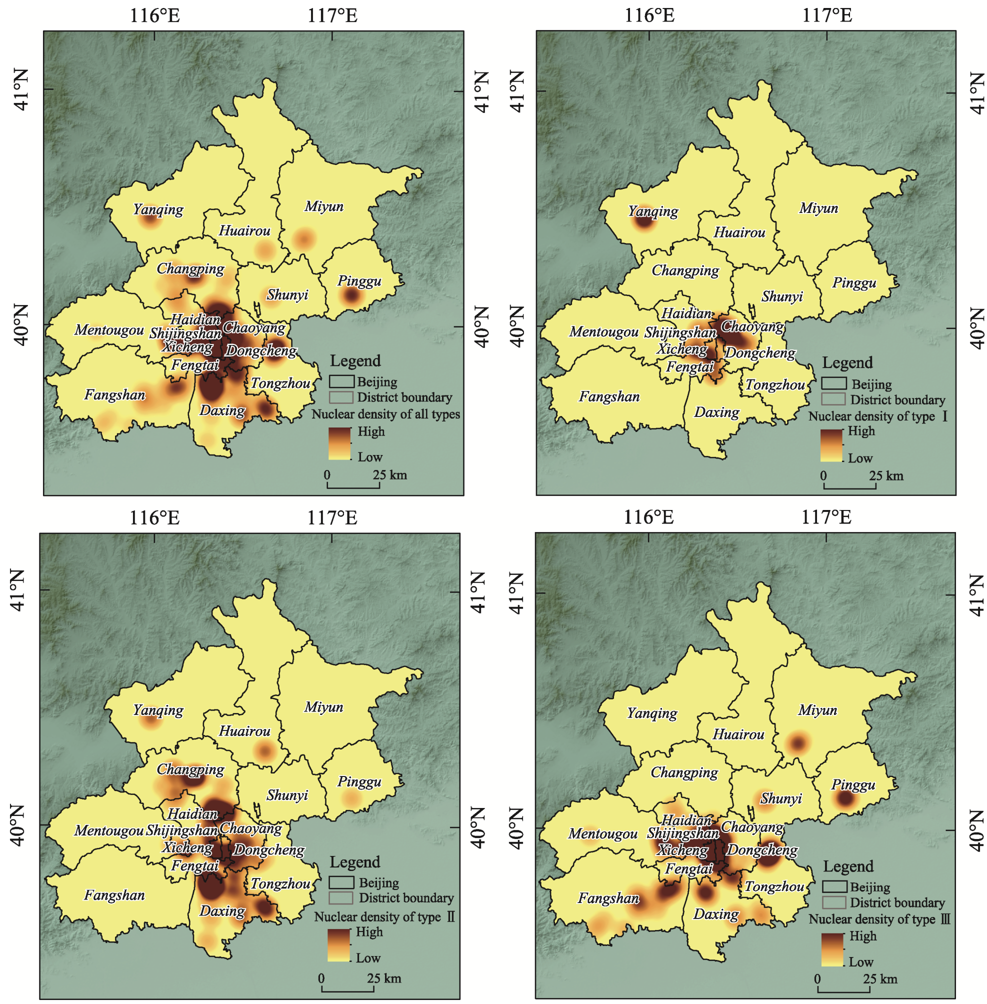

Figure 2 Maps of the kernel density of earthquake emergency shelters in Beijing

Typological analysis revealed that the high kernel density areas of Type I earthquake emergency shelters (maximum value: 0.049) are concentrated in Chaoyang District, Xicheng District, Dongcheng District, and the western part of Yanqing District. For Type II shelters (maximum value: 0.146), the high-density areas are located in Xicheng District, Dongcheng District, eastern Shijingshan District, northern Daxing District, and central Changping District. The high-density areas of Type III shelters (maximum value: 0.146) are primarily distributed in Xicheng District, Dongcheng District, eastern Shijingshan District, northern Daxing District, eastern Fangshan District, northern Tongzhou District, and southern Pinggu District.

5 Discussion and Conclusion

Optimizing the spatial layout of earthquake emergency shelters is a critical step in enhancing urban resilience and public safety. This dataset provides detailed information on 180 earthquake emergency shelters in Beijing (2021–2025) released by the Beijing Municipal

Emergency Management Bureau, covering attribute data such as serial number, name, type, era, and address, as well as spatial data including geographic coordinates and administrative divisions of each shelter. The dataset is intended to support in-depth pattern discovery and refined analysis in the field of urban comprehensive disaster prevention, thereby fostering the integration of scientific research and practical management. It provides essential data support for optimizing the spatial distribution of shelters, improving urban emergency response capabilities, and strengthening societal resilience in Beijing.

Analysis of this dataset reveals significant spatial differentiation of earthquake emergency shelters within the central urban area of Beijing. High-density service areas are heavily clustered in the city's core functional zones, resulting in an overall imbalance in the shelter network. Peripheral areas, in contrast, often experience poor accessibility, and in some cases, shelters may be entirely unavailable.

Future planning of earthquake emergency shelters should consider the existing distribution and make better use of public spaces such as green areas, squares, and schools in the central urban area to optimize or expand shelter facilities. Existing shelters should be upgraded to better meet residents' needs. Additionally, planning should align with adjustments in the capital's functional layout and potential population relocations to alleviate pressure on shelters in the central urban area and move toward a more balanced spatial distribution. At the national level, spatial planning should combine spatial adaptability with a high-level security and resilience framework, prioritize the safety needs of residents, and promote coordinated urban development and protection. By applying a sense of crisis and proactive planning, continuously improving urban safety systems, and establishing a more efficient operational framework, Beijing can better respond to complex risks and progress toward higher resilience goals.

Despite the comprehensive information provided by this dataset, it has considerable potential for further development and data mining. Future improvements could include 3 main aspects: at the basic data level, establishing standardized cleaning processes to denoise, complete, and unify existing data formats, and integrating IoT devices to collect real-time dynamic data such as environmental conditions and traffic. At the scientific discovery level, collaboration with research institutions could embed disaster warning models and AI algorithms, improving prediction accuracy through machine learning-based data association mining. At the level of social sustainable development, integrating community feedback, economic indicators, and other data could support the construction of a multidimensional evaluation system to quantify the impact of policies on safety and the environment.

Author Contributions

Cheng, L. was responsible for the overall design of the study; Cheng, L., Sheng, S. Q. and Ma, Y. designed the methodology; Zhang, X., Ma, Y. and Cheng, L. conducted software implementation; Ma, Y., Zhang, X. and Cheng, L. performed formal analysis; Zhang, X. and Ma, Y. carried out the investigation; Ma, Y., Zhang, X. and Sheng, S. Q. were responsible for data curation; Sheng, S. Q. and Cheng, L. wrote the original draft; Cheng, L. reviewed and edited the manuscript; Ma, Y. and Zhang, X. completed the visualization. All authors have reviewed the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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