

# Dataset Development of Identifying China's Metropolitan Area Using DBSCAN Clustering Under Dominant Flow Constraints

Li, J. Zhang, Y.\* Tang, S. Liu, X. H.

College of Geography and Planning, Chengdu University of Technology, Chengdu 610059, China

**Abstract:** Metropolitan areas are a vital spatial unit for advancing new-type urbanization and fostering high-quality development. Scientific delineation of metropolitan boundaries is fundamental for conducting related research and guiding planning practices. Building on a clear conceptual framework, this study initially identifies central cities, then constructs an intercity human mobility network using Baidu Migration data, and finally delineates the spatial extent of China's metropolitan areas through DBSCAN (Density-Based Spatial Clustering of Applications with Noise) clustering under dominant flow constraints. The resulting dataset includes: (1) a list of metropolitan core cities and their spatial distribution, (2) a matrix of intercity human mobility intensities and the corresponding mobility network, (3) the delineated metropolitan areas and their spatial distribution. The dataset is archived in .shp and .xlsx formats, comprising 29 data files with a total size of 67.9 MB (compressed into a single file of 31.3 MB).

**Keywords:** metropolitan area identification; human mobility network; central cities; dominant flow constraint; DBSCAN clustering

**DOI:** <https://doi.org/10.3974/geodp.2025.03.04>

**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.2025.08.01.V1>.

## 1 Introduction

Metropolitan areas are essentially functional urban regions<sup>[1]</sup>. Metropolitan areas typically emerged through the diffusion and radiation effects of large, comprehensive cities, which drive the coordinated development of surrounding small and medium-sized cities. Over time, these interactions give rise to densely connected urban regions with deeply integrated functions<sup>[2]</sup>. The spatial scope of metropolitan areas is generally smaller than that of city clusters, representing the core zones within broader urban agglomerations<sup>[3,4]</sup>. As a key

---

**Received:** 03-06-2025; **Accepted:** 29-08-2025; **Published:** 25-09-2025

**Foundation:** National Natural Science Foundation of China (42501258, 52478045)

\***Corresponding Author:** Zhang, Y., College of Geography and Planning, Chengdu University of Technology, zhangyang2020@cdut.edu.cn

**Data Citation:** [1] Li, J., Zhang, Y., Tang, S., *et al.* Dataset development of identifying China's metropolitan area using DBSCAN clustering under dominant flow constraints [J]. *Journal of Global Change Data & Discovery*, 2025, 9(3): 290–298. <https://doi.org/10.3974/geodp.2025.03.04>.

[2] Li, J., Zhang, Y., Tang, S., *et al.* Dataset for identifying Chinese metropolitan areas using DBSCAN clustering under dominant flow constraints [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2025. <https://doi.org/10.3974/geodb.2025.08.01.V1>.

vehicle for advancing the national strategy of new-type urbanization and achieving high-quality development, metropolitan areas have gained increasing prominence<sup>[5–7]</sup>. In recent years, their development has been consistently prioritized at the national strategic level. For example, the National new-type urbanization plan (2014–2020) emphasized the construction of integrated metropolitan areas characterized by efficient commuting and coordinated development. Subsequently, in 2019, China's government issued the Guidelines on fostering the development of modern metropolitan areas, further advancing the construction of metropolitan areas toward modernization and high-quality development. More recently, China's government reiterated the importance of leveraging urban agglomerations and metropolitan areas to establish a coordinated development pattern among large, medium, and small cities. As a foundation for planning practices and academic research, the scientific delineation of metropolitan spatial boundaries provides essential references for optimizing cross-regional resource allocation, promoting urban-rural integration, and fostering high-quality new-type urbanization.

The accelerating processes of globalization and informatization have intensified the flows of key elements—such as population, goods, information, capital, and technology—across cities, profoundly reshaping urban networks and influencing the emergence and evolution of metropolitan areas<sup>[8]</sup>. However, conventional methods for identifying metropolitan areas rely primarily on static spatial analysis<sup>[9,10]</sup>, typically incorporating attribute data such as the proportion of non-agricultural population<sup>[11]</sup>, population size<sup>[11]</sup>, and secondary and tertiary industry output, alongside spatial proximity factors<sup>[12]</sup>. These approaches often overlook the spatial interaction effects of dynamic factor flows. In recent years, the rapid development of big data technologies has enabled access to diverse and low-cost geographic flow data, presenting new opportunities for metropolitan areas identification<sup>[13]</sup>. Therefore, this study identifies central cities, constructs a national intercity population flow network using Baidu migration data, and applies DBSCAN clustering under dominant flow constraints to delineate the spatial extent of metropolitan areas in China.

## 2 Metadata of the Dataset

The metadata for the Dataset for identifying Chinese metropolitan areas using DBSCAN clustering under dominant flow constraints<sup>[14]</sup>, including the title, authors, geographical region, data format, data size, data files, data publication and sharing platform, and data sharing policy, are summarized in Table 1.

## 3 Methods

### 3.1 Data Sources

The data used in this study primarily comprise socio-economic statistics and Baidu migration data. Socio-economic indicators, including permanent resident population and GDP (Gross Domestic Product), are derived from the China city statistical yearbook 2020<sup>[16]</sup>. Baidu migration data, supported by large-scale location-based service technologies, dynamically capture population flows, directions, and migration intensities among cities across different time periods, and have been widely applied in studies of urban networks<sup>[17]</sup>. In this study, we utilized intercity inflow and outflow data covering 365 China's cities (excluding Hong Kong, Macao, and Taiwan due to data unavailability) from January 1 to January 14, 2020, a period encompassing weekdays, weekends, and statutory holidays<sup>1</sup>. Rigorous data cleaning and preprocessing were subsequently conducted, including duplicate

<sup>1</sup> Baidu Migration platform on Baidu Map Insight. <https://huiyan.baidu.com>.

removal, missing-value imputation, anomaly detection, standardized formatting, and calibration, to ensure data reliability and consistency. Finally, based on the preprocessed inflow-outflow records, we then constructed a population migration intensity matrix across the 365 cities.

**Table 1** Metadata summary of the Dataset for identifying Chinese metropolitan areas using DBSCAN clustering under dominant flow constraints

Items	Description
Dataset full name	Dataset for identifying Chinese metropolitan areas using DBSCAN clustering under dominant flow constraints
Dataset short name	MetropolitanAreaDelineation
Authors	Li, J., College of Geography and Planning, Chengdu University of Technology, lijuan@stu.cdut.edu.cn Zhang, Y., College of Geography and Planning, Chengdu University of Technology, zhangyang2020@cdut.edu.cn Tang, S., College of Geography and Planning, Chengdu University of Technology, 2910356995@qq.com Liu, X. H., College of Geography and Planning, Chengdu University of Technology, 1303940151@qq.com
Geographical region	365 municipal units in China (data for Hong Kong, Macao and Taiwan is temporarily unavailable)
Year	2020
Data format	.shp, .xlsx
Data size	31.3 MB (after compression)
Data files	(1) Central cities list and their spatial distribution; (2) A matrix of intercity human mobility intensity and the corresponding mobility network; (3) Identified metropolitan areas and their spatial distribution
Foundation	National Natural Science Foundation of China (52478045)
Data publisher	Global Change Research Data Publishing & Repository, <a href="http://www.geodoi.ac.cn">http://www.geodoi.ac.cn</a>
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) <i>Data</i> are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use <i>Data</i> subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute <i>Data</i> subject to written permission from the GCdataPR Editorial Office and the issuance of a <i>Data</i> redistribution license; and (4) If <i>Data</i> are used to compile new datasets, the “ten percent principal” should be followed such that <i>Data</i> records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset <sup>[15]</sup>
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

## 3.2 Model and Experimental Design

### 3.2.1 Calculation of Human Flow Connection Intensity

Owing to directional differences in population inflows and outflows among cities, the intensity of population flow connections between city  $i$  and city  $j$  is calculated as the sum of the population inflow and outflow intensities. This approach eliminates the directionality inherent in population flow connections. The Equation for calculating the intensity of population flow connections between two cities is as follows<sup>[18]</sup>:

$$P_{ij} = P_{i,j} + P_{j,i} \quad (1)$$

where the scales of population flow connections from city  $i$  to city  $j$  and from city  $j$  to city  $i$  are denoted by  $P_{i,j}$  and  $P_{j,i}$ .

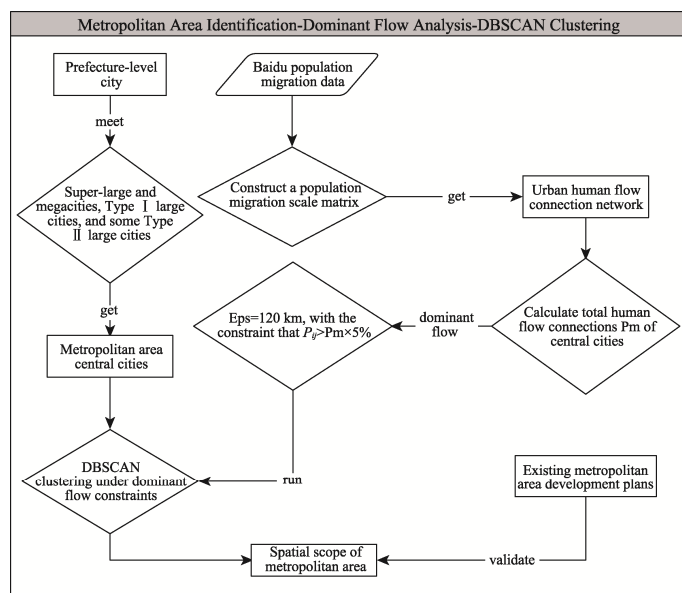
### 3.2.2 DBSCAN Clustering under Dominant Flow Constraints

DBSCAN is a density-based clustering algorithm that identifies clusters by specifying a neighborhood radius (Eps) and a minimum number of points (MinPts). Core points are those with a sufficient number of neighbors within the Eps radius, and clusters are formed by linking core points with their density-reachable neighbors. Owing to its ability to detect arbitrarily shaped clusters, distinguish high-density regions, and effectively handle noise,

DBSCAN has been widely applied in spatial data clustering and complex network community detection<sup>[19]</sup>. For flow-based data scenarios such as urban interaction networks, Zhang, *et al.*<sup>[20]</sup> innovatively integrated dominant flow analysis with the DBSCAN algorithm to propose an improved spatial clustering approach. This method extends conventional density-based clustering by introducing dominant inter-node flows as a constraint condition<sup>[21]</sup>. By simultaneously accounting for geographical proximity and network connectivity strength, it enables a more rigorous and scientifically grounded delineation of metropolitan spatial boundaries.

### 3.3 Technical Route

The development process of this dataset comprises 3 main steps: (1) identification of metropolitan core cities, (2) construction of the national population mobility network and dominant flow analysis, and (3) delineation of metropolitan spatial boundaries (Figure1).



**Figure 1** Flowchart of dataset development

#### 3.3.1 Identification of Metropolitan Area Central Cities

Based on the definitions of core cities provided in the national Technical guidelines for territorial spatial planning of metropolitan areas<sup>[22]</sup> and the Guiding opinions on fostering and developing modern metropolitan areas<sup>[23]</sup>, this study prioritizes the selection of metropolitan cores among China's cities. Specifically, we identify 7 megacities, 14 very large cities, and 14 Type I large cities with central urban district populations exceeding 3 million as metropolitan core cities. In accordance with the research by Shen, *et al.*<sup>[24]</sup>, the population threshold for central cities in metropolitan areas may be appropriately lowered in Western China. Accordingly, 12 Type II large cities in Western China, with urban district populations ranging from 1 to 3 million, are also included as metropolitan core cities. Although their populations fall below the 3 million benchmark, these cities exert strong spatial influence over surrounding areas and are often provincial capitals or central nodes within urban glomerations. A total of 47 cities were identified as metropolitan core cities for this study.

#### 3.3.2 Construction of Urban Human Flow Connection Network

Following the preprocessing of Baidu migration data, a daily population migration matrix

was constructed based on intercity in-migration and out-migration flows. Subsequently, a population mobility intensity matrix was derived using Equation 1, which aggregates bidirectional flows to quantify the strength of intercity population connections. This matrix was then visualized and classified into discrete levels using the natural breaks (Jenks) method. Based on the classification results, the spatial structure of the intercity population mobility network was identified, and a dominant flow analysis was conducted to reveal the hierarchical organization and directional characteristics of the network.

### 3.3.3 Identification of Metropolitan Area Spatial Scope

In this dataset, the identification radius of metropolitan areas is set to 120 km, based on 2 key factors: the maximum average intercity distance among existing planned metropolitan areas and the spatial coverage of the one-hour commuting circle. To incorporate network connectivity, a dominant flow threshold was introduced, whereby intercity population flow intensity exceeding 5% of the total flow of the core city was defined as a clustering constraint. The improved DBSCAN clustering algorithm was implemented in a Node.js runtime environment using JavaScript on the VS Code platform. Starting from a core city point  $p$  in the set of core cities  $D$ , if the number of cities within its Eps neighborhood exceeds the minimum threshold (MinPts),  $p$  is identified as a core point. Subsequently, a cluster is initialized with  $p$  as its center, and cities within its Eps neighborhood are added to the cluster. During cluster expansion, the dominant flow constraint is applied to ensure that only cities with strong population linkages to the core city (i.e., exceeding the threshold) are included. This approach enables the identification of the spatial extent of metropolitan areas centered on each core city, integrating geographic proximity and network connectivity.

## 4 Data Results and Validation

### 4.1 Dataset Composition

The dataset comprises 3 components: (1) the list and spatial distribution of metropolitan core cities, provided in .xlsx and .shp formats; (2) the intercity population mobility intensity matrix and the corresponding mobility network among 365 cities, available in .xlsx and .shp formats; (3) the identification results and spatial distribution of metropolitan areas across China, also provided in .xlsx and .shp formats.

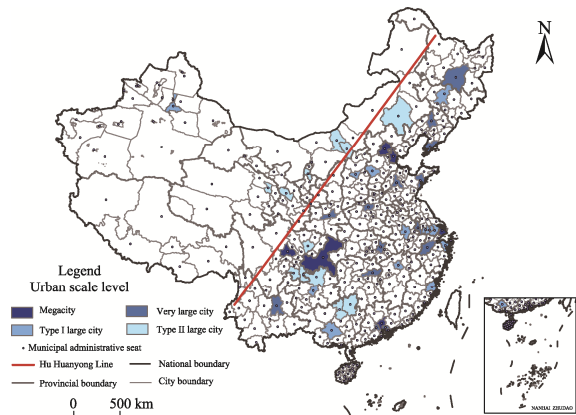
### 4.2 Data Results

A total of 47 metropolitan core cities were identified through the selection process (Figure 2), including 7 megacities, 14 very large cities, 14 Type I large cities, and 12 Type II large cities. Most of these core cities are located southeast of the Hu Huanyong Line, reflecting the stronger capacity for population agglomeration and spatial radiation in the eastern region. By contrast, most cities in the western region, aside from several provincial capitals, exhibit limited capacity to drive regional development.

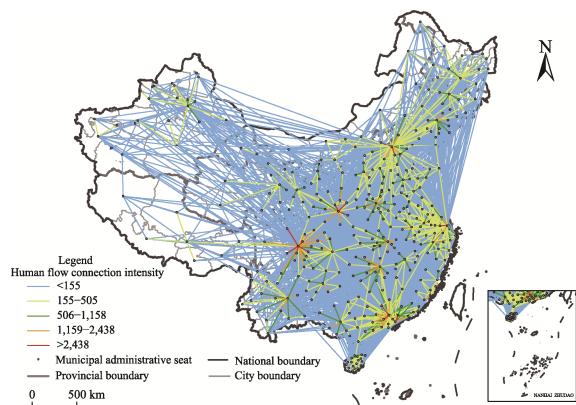
As shown in Figure 3, the overall structure of China's intercity population flow network reveals a pattern of higher density and stronger linkages in the east, and lower density with weaker linkages in the west. Major urban agglomerations—such as the Yangtze River Delta, Beijing-Tianjin-Hebei, Pearl River Delta, and Chengdu-Chongqing—constitute the primary clusters of high-intensity flows. Within these regions, core cities including Beijing, Shanghai, Shenzhen, Chengdu, and Chongqing function as central hubs, radiating strong connections outward. Several provincial capitals, such as Xi'an, Kunming, Changsha, and Wuhan, also serve as important sources of high-intensity flows. The distribution of flow intensities across different levels is markedly uneven. High-level flows account for a smaller proportion and are predominantly characterized by short-distance interactions, whereas low-level flows are more

widely distributed and tend to span longer distances.

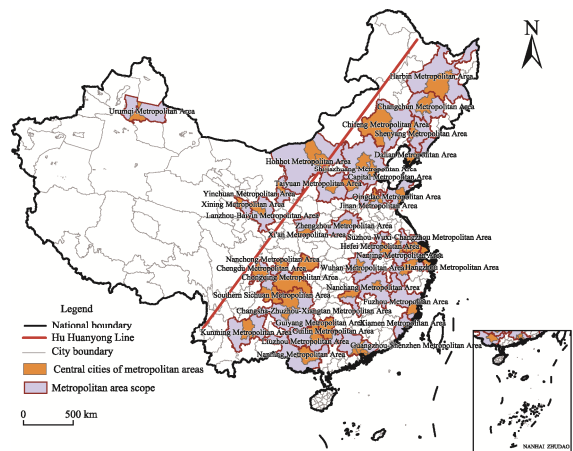
By setting the metropolitan area identification radius and applying dominant flow constraints, the resulting metropolitan area delineations are presented in Figure 4 and Table 2, yielding a total of 37 metropolitan areas. Due to Shanghai's extensive population mobility connections with cities nationwide, and the absence of clear dominant flows with its immediate neighbors, Shanghai was not included within the spatial boundaries of any metropolitan area. Overall, the spatial distribution of metropolitan areas in China reveals a pattern of dense concentration in the southeast and sparse distribution in the northwest. With the exception of Urumqi, Xining, Lanzhou-Baotou, Yinchuan, and Hohhot, all identified metropolitan areas are located southeast of the Hu Huanyong Line. Key urban agglomerations, such as the Beijing-Tianjin-Hebei, the Yangtze River Delta, the Pearl River Delta, and Chengdu-Chongqing, form dense clusters of metropolitan areas. The identified metropolitan areas exhibit a coexistence of single-center, dual-center, and multi-center structures. For example, the Guangzhou-Shenzhen and Suzhou-Wuxi-Changzhou Metropolitan Areas are classified as multi-center, whereas the Capital, Southern Sichuan, Guiyang, and Hohhot Metropolitan Areas are dual-center. The core cities within these metropolitan areas tend to be of comparable size, reflecting either strong cooperation between equals or a dominant core city supported by multiple secondary centers. The combined GDP of the 37 metropolitan areas accounts for 64.76% of the national total. Notably, the Guangzhou-Shenzhen and Capital Metropolitan Areas stand out as more mature and developed, leading all metropolitan areas in GDP and resident population size. These areas also serve as hubs of high-level population mobility flows, demonstrating elevated economic activity and strong population attraction.



**Figure 2** Distribution map of central cities in metropolitan areas



**Figure 3** Network map of urban human flow connections



**Figure 4** Distribution map of metropolitan area identification results

**Table 2** Identification results of metropolitan areas

Metropolitan area name	Central city	Component cities	Population (10,000 persons)	Area (km <sup>2</sup> )	GDP (100 million CNY)
Suzhou-Wuxi-Changzhou Metropolitan Area	Suzhou, Wuxi, Changzhou	Suzhou, Wuxi, Changzhou, Nantong	3,362.80	25,670.78	66,225.79
Nanjing Metropolitan Area	Nanjing	Nanjing, Zhenjiang, Yangzhou, Wuhu, Ma'anshan, Xuancheng	2,587.98	37,913.25	41,809.10
Hangzhou Metropolitan Area	Hangzhou	Hangzhou, Huzhou, Jiaxing, Shaoxing, Quzhou, Huangshan	3,074.20	53,837.00	45,408.26
Hefei Metropolitan Area	Hefei	Hefei, Huainan, Lu'an, Bengbu	2,058.70	38,335.00	19,844.19
Ningbo Metropolitan Area	Ningbo	Ningbo, Zhoushan	1,095.30	11,216.00	20,373.90
Nanchang Metropolitan Area	Nanchang	Nanchang, Jiujiang, Fuzhou, Yichun, Shangrao	2,595.40	86,516.59	21,427.15
Changsha-Zhuzhou-Xiangtan Metropolitan Area	Changsha	Changsha, Zhuzhou, Xiangtan	1,693.31	28,069.70	22,128.24
Wuhan Metropolitan Area	Wuhan	Wuhan, Ezhou, Huangshi, Huanggang, Xiaogan, Xianning, Xiantao	3,166.11	53,657.05	33,398.22
Fuzhou Metropolitan Area	Fuzhou	Fuzhou, Putian, Nanping, Ningde	1,748.30	55,828.24	23,671.79
Xiamen Metropolitan Area	Xiamen	Xiamen, Zhangzhou, Quanzhou	1,934.00	25,315.61	27,747.59
Guangzhou-Shenzhen Metropolitan Area	Guangzhou, Foshan, Dongguan, Shenzhen	Guangzhou, Foshan, Dongguan, Shenzhen, Huizhou, Qingyuan, Zhaoqing	7,147.68	60,942.97	104,785.73
Nanning Metropolitan Area	Nanning	Nanning, Qinzhou, Guigang, Fangchenggang, Chongzuo, Baise	2,408.89	103,366.00	15,096.76
Liuzhou Metropolitan Area	Liuzhou	Liuzhou, Hechi, Laibin	951.99	65,500.00	5,385.24
Guilin Metropolitan Area	Guilin	Guilin, Hezhou	696.12	39,552.64	3,481.81
Guiyang Metropolitan Area	Guiyang	Zunyi, Guiyang, Zunyi, Tongren, Bijie, Anshun, Qiannan, Qiandongnan	3,263.93	149,418.00	19,477.66
Chongqing Metropolitan Area	Chongqing	Chongqing, Guang'an	3,517.17	88,744.00	33,808.65
Southern Sichuan Metropolitan Area	Yibin, Luzhou	Yibin, Luzhou, Zigong, Neijiang	1,438.4	35,273.18	10,661.07
Chengdu Metropolitan Area	Chengdu	Chengdu, Ziyang, Deyang, Meishan	3,009.10	33,104.00	29,756.75
Nanchong Metropolitan Area	Nanchong	Nanchong, Suining	823.70	17,822.25	4,731.96
Kunming Metropolitan Area	Kunming	Kunming, Qujing, Yuxi, Chuxiong Yi Autonomous Prefecture	1,891.40	93,671.95	16,553.44
Xi'an Metropolitan Area	Xi'an	Xi'an, Xianyang, Tongchuan, Weinan	2,253.62	37,304.51	19,065.60
Zhengzhou Metropolitan Area	Zhengzhou	Zhengzhou, Xinxiang, Jiaozuo, Kaifeng, Xuchang, Pingdingshan, Luoyang	4,373.10	54,276.00	35,323.77
Jinan Metropolitan Area	Jinan	Jinan, Zibo, Tai'an, Liaocheng	2,533.98	32,599.45	25,201.74
Qingdao Metropolitan Area	Qingdao	Qingdao, Weifang, Rizhao, Yantai	2,974.58	46,750.90	38,262.38
Dalian Metropolitan Area	Dalian	Dalian, Yingkou, Dandong	1,187.80	33,027.81	12,085.00
Shenyang Metropolitan Area	Shenyang	Shenyang, Tieling, Fushun, Benxi, Liaoyang, Anshan	1,925.10	59,535.77	14,937.50

*(To be continued on the next page)*

*(Continued)*

Metropolitan area name	Central city	Component cities	Population (10,000 persons)	Area (km <sup>2</sup> )	GDP (100 million CNY)
Harbin Metropolitan Area	Harbin	Harbin, Mudanjiang, Daqing, Suihua, Yichun, Jiamusi	2,003.63	213,467.00	12,505.70
Changchun Metropolitan Area	Changchun	Changchun, Jilin, Siping, Liaoyuan, Songyuan	1,728.63	92,989.00	11,375.87
Chifeng Metropolitan Area	Chifeng	Chifeng, Tongliao, Chaoyang	946.38	169,255.14	5,161.50
Hohhot Metropolitan Area	Hohhot, Baotou	Hohhot, Baotou, Ordos, Bayannur, Ulanqab	1,172.17	251,500.00	17,401.71
Yinchuan Metropolitan Area	Yinchuan	Yinchuan, Wuzhong, Shizuishan	504.61	35,735.38	4,438.78
Capital Metropolitan Area	Beijing, Tianjin	Tianjin, Beijing, Zhangjiakou, Chengde, Baoding, Langfang, Cangzhou, Tangshan	7,233.97	160,101.00	94,878.72
Shijiazhuang Metropolitan Area	Shijiazhuang	Shijiazhuang, Hengshui, Xingtai	2,225.43	35,701.00	12,941.10
Taiyuan Metropolitan Area	Taiyuan	Taiyuan, Xinzhou, Yangquan, Jinzhong, Lvliang	1,605.84	74,238.63	12,720.51
Lanzhou-Baiyin Metropolitan Area	Lanzhou	Baiyin, Lanzhou, Linxia, Dingxi	1,049.00	60,969.00	5,728.28
Xining Metropolitan Area	Xining	Xining, Haidong	380.55	20,860.00	2,467.56
Urumqi Metropolitan Area	Urumqi	Urumqi, Changji Hui Autonomous Prefecture	576.15	87,300.00	7,011.39

### 4.3 Data Validation

A comparative validation between the identified metropolitan areas and those officially approved by the national government reveals a high degree of spatial overlap for most cases, including the Chengdu, Chongqing, Changsha-Zhuzhou-Xiangtan, and Xi'an Metropolitan Areas. Some differences also emerge, for example, the Guangzhou-Shenzhen Metropolitan Area was identified as a single entity due to the strong population mobility connections between Guangzhou and Shenzhen. This outcome supports the scientific validity of applying the DBSCAN clustering algorithm constrained by dominant flows to delineate metropolitan spatial boundaries. Moreover, 20 metropolitan areas that have not yet received official national approval were identified. These metropolitan areas demonstrate substantial population and economic scale, as well as strong internal population mobility linkages, indicating significant potential for development into modern metropolitan areas. Notable examples include the Southern Sichuan, Hohhot, Dalian, and Nanning Metropolitan Areas.

## 5 Discussion and Conclusion

This dataset constructs an intercity population mobility network using Baidu migration data and applies a DBSCAN clustering algorithm constrained by dominant flows. Through an integrated identification framework, comprising “core city selection, dominant flow analysis, and dynamic clustering”, it provides a scientific delineation of metropolitan areas in China. The metropolitan areas identified through this approach are largely consistent with the core regions defined in existing plans, while encompassing a more complete spatial extent. This finding reflects strong scientific rigor and practical applicability, providing methodological reference and empirical evidence for delineating metropolitan boundaries and informing planning policy in China. Future research could incorporate multidimensional element flows, such as technology and information flows, to further enhance the methodology. In addition, the metropolitan area identification results may be used to conduct competitiveness assessments and development tier classifications, supporting differentiated planning and policy formulation tailored to various stages of metropolitan development.

### Author Contributions

Li, J. was responsible for data visualization and paper writing. Zhang, Y. proposed the overall framework for dataset development and supervised the manuscript. Tang, S. acquired and processed human flow data and other related basic data. Liu, X. H. designed and implemented the model and algorithm for metropolitan area delineation.

### Conflicts of Interest

The authors declare no conflicts of interest.

### References

- [1] Zhou, Y. X., Shi, Y. L. Establishing the concept of physical territory of Chinese cities [J]. *Acta Geographica Sinica*, 1995(4): 289–301.
- [2] Niu, X. Y., Li, K. K. Implementation monitoring of territorial spatial planning for metropolitan areas from the perspective of cross-city functional connections [J]. *Resources Science*, 2021, 43(2): 380–389.
- [3] Zhang, J. X., Hu, H. J. Development, planning and governance innovation of metropolitan areas in the new development environment [J]. *Economic Geography*, 2023, 43(1): 17–25.
- [4] Yuan, J. D., Zhou, J., Huang, W. Several misunderstandings in the theoretical research and planning practice of metropolitan areas in China [J]. *Geographical Research*, 2006(1): 112–120.
- [5] Zhang, Y. S., Huang, J. Z., Wang, Q. X., et al. Research on the construction ideas of China's metropolitan area governance model from the perspectives of "scale reorganization" and "meta-governance" [J]. *Planners*, 2023, 39(4): 19–27.
- [6] Zhang, J. X., Zou, J., Wu, Q. Y., et al. On the organization of metropolitan area space [J]. *City Planning Review*, 2001(5): 19–23.
- [7] Wang, G. T., Li, F., Liu, X., et al. Research on the new pattern of urbanization in the new development stage—concept and identification criteria of modern metropolitan areas [J]. *Urban Planning Forum*, 2021(2): 15–24.
- [8] Ma, L. Y., Xiu, C. L., Feng, X. H. Analysis of urban network characteristics in Northeast China from the perspective of multiple flows [J]. *Economic Geography*, 2019, 39(8): 51–58.
- [9] Stone, L. O. On the correlation between metropolitan area in-and out-migration by occupation [J]. *Journal of the American Statistical Association*, 1971, 66(336): 693–701.
- [10] Feria, J. M., Casado-Díaz, J. M., Martínez-Bernabeu, L. Inside the metropolis: the articulation of Spanish metropolitan areas into local labor markets [J]. *Urban Geography*, 2015, 36(7): 1018–1041.
- [11] Yang, Y. C., Zhang, C. G., Wu, W. X. Study on the development planning of metropolitan areas in Western China—a case study of Lanzhou Metropolitan Area Planning [J]. *City Planning Review*, 2005(4): 23–29.
- [12] Zou, J., Chen, X. H. Re-understanding of urban system spatial planning—taking Jiangsu as an example [J]. *City Planning Review*, 2001(1): 30–33.
- [13] Yang, Y., Yin, D., Liu, Z. W., et al. Research progress of flow space based on big data [J]. *Progress in Geography*, 2020, 39(8): 1397–1411.
- [14] Li, J., Zhang, Y., Tang, S., et al. Dataset for identifying Chinese metropolitan areas using DBSCAN clustering under dominant flow constraints [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2025. <https://doi.org/10.3974/geodb.2025.08.01.V1>.
- [15] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. <https://doi.org/10.3974/dp.policy.2014.05> (Updated 2017).
- [16] Urban Social and Economic Survey Department of the National Bureau of Statistics of China. China Urban Statistical Yearbook (2020) [M]. Beijing: China Statistics Press, 2021.
- [17] Zhan, C., Tse, C. K., Fu, Y. X., et al. Modeling and prediction of the 2019 coronavirus disease spreading in China incorporating human migration data [J]. *Plos One*, 2020, 15(10): e0241171.
- [18] Zhang, Y., Zhao, Y. B., Zhao, J. J., et al. Research on the network structure characteristics of Chengdu-Chongqing Urban Agglomeration based on human flow-logistics-information flow [J]. *Areal Research and Development*, 2023, 42(6): 40–45.
- [19] Li, X. Y., Li, D. R. DBSCAN spatial clustering algorithm and its application in urban planning [J]. *Science of Surveying and Mapping*, 2005(3): 51–53+5.
- [20] Zhang, Y., Li, J., Wang, X. P. Research on the spatial structure characteristics of Chengdu-Chongqing Urban Agglomeration from the perspective of multidimensional element flows [J]. *Western Human Settlements*, 2024, 39(3): 14–20.
- [21] Zheng, L., Long, F., Zhang, S. Comparison of the spaces of call and traffic flows: an empirical study of Qianzhong urban region, China [J]. *Cities*, 2020, 107, 102927.
- [22] Ministry of Natural Resources of P. R. China. Official implementation of Regulations on the compilation of territorial spatial planning for metropolitan areas [EB/OL]. (2024-04-02) [2025-07-30]. [https://www.mnr.gov.cn/dt/ywbb/202404/t20240402\\_2841150.html](https://www.mnr.gov.cn/dt/ywbb/202404/t20240402_2841150.html).
- [23] National Development and Reform Commission of P. R. China. Guiding opinions on fostering and developing modern metropolitan areas [EB/OL]. (2019-02-19) [2025-07-30]. <https://zfxgk.ndrc.gov.cn/web/iteminfo.jsp?id=16110>.
- [24] Shen, M. R., Wang, Z. Q., Cui, G. H. Metropolitan areas in China: theoretical origin and planning practice [J]. *Urban Planning Forum*, 2023(2): 57–66.