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Boundary Dataset of Built-up Areas in Chengdu-Chongqing Economic Circle Based on POI&ISA Composite Index (2010, 2020)

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Abstract: Urban built-up area is an important basic information for urban planning and construction management, which can reflect the urbanization process and urban spatial pattern. Accurate extraction of urban built-up areas' boundaries is of great significance for promoting sustainable urban development. We using Landsat TM/OLI images in 2010/2020 and electronic map points of interest as data source to construct a comprehensive index (POI&ISA) reflecting the build-up level of cities, then through the best threshold selection developing a proper boundary dataset of built-up areas in Chengdu-Chongqing economic circle. This dataset includes boundaries data and areas data of the built-up area in the Chengdu-Chongqing economic circle which combining the landscape and functional features. Dataset is archived in .shp and .xlsx data formats, consisting of 257 data files with data size of 974 KB (compressed into 1 file, 611 KB).

Keywords: built-up area; POI&ISA index; Chengdu-Chongqing economic circle; electronic map point of interest; impervious surface

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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.2023.09.02.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2023.09.02.V1.

1 Introduction

Urban built-up area refers to that[1] in the urban administrative region that has actually been developed and constructed, with basically available municipal and public facilities. The

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[2] Zhu, Y. L., Zhang, Y., Yang, R. Z., *et al*. Boundary dataset of built-up areas in Chengdu-Chongqing urban economic circle based on POI&ISA composite index (2010, 2020) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2023. https://doi.org/10.3974/geodb.2023.09.02.V1. https://cstr.escience.org.cn/CSTR:20146.11.2023.09.02.V1.

boundary of the area serves as an effective reflection of the urbanization process and urban spatial pattern and provides an basic information for urban planning, construction and management[2,3]. It is widely used in the demarcation of urban development boundaries and the layout of public service facilities. In the context of the new urbanization strategy, precise demarcation of urban built-up area boundaries proves helpful in the quality assessment of urbanization quality and the optimization of urban spatial patterns, which holds great significance for sustainable urban development.

The urban built-up area includes the characteristics of both landscape and function. In terms of landscape, it is mainly reflected in the physical development and construction, with artificial surfaces dominating the area; in terms of function, it requires basic municipal and public facilities. Existing extraction methods have mainly focused on the landscape characteristics of urban built-up areas, wherein contiguous constructed land is identified as part of the urban built-up area. This includes techniques such as the neighborhood expansion method[4] and the normalized difference built-up index(NDBI)[5]. With the advent of various forms of geographic big data in the information age, an increasing number of studies have shifted their attention towards the functional characteristics of urban built-up areas. They classify areas with relatively higher levels of social and economic development into built-up areas and have successively proposed a variety of extraction methods[6–8] based on electronic map points of interest (POI) and night light images. In 2021, the Ministry of Natural Resources issued the industry standard of “Regulations for Urban Scope determination”, which places stringent demands on the basic data extracted from the built-up areas and involves a relatively complex process[9,10]. Meanwhile, it suggests the use of big data and other means for auxiliary judgment. Zhang *et al.*[11] comprehensively considered the actual surface coverage and the configuration of municipal public facilities and public facilities. They developed the built-up area comprehensive index (POI&ISA) based on POI and impervious surface index, which achieved high accuracy in the extraction of the built-up area of Wuhan.

The Chengdu-Chongqing region has always held an essential position in the national regional strategic layout. In 2011, there was an initial integration of the spatial layout of the entire urban system. In 2014, the sixth meeting of the Chengdu-Chongqing economic circle was established as a national strategy. In recent years, the central cities of the Chengdu-Chongqing economic circle have seen continuous enhancement of their radiating and driving influence, which accelerated the development of small and medium-sized cities coupled with gradual improvements in infrastructure. However, there is still a big gap between these cities and the more developed urban centers in the eastern regions. Accurate extraction of the urban built-up areas of the Chengdu-Chongqing economic circle is not only beneficial for understanding the characteristics of the urban development stage in this region but also serves as an essential step to support the goal proposed in the Planning Outline of Chengdu-Chongqing economic circle: “seamless matching between the social and economic development goals and the spatial support system”.

2 Metadata of the Dataset

The metadata of Boundary dataset of built-up areas in Chengdu-Chongqing economic circle based on POI&ISA composite index (2010, 2020)[12] is summarized in Table 1.

3 Data Source and Methods

3.1 Data Source

The basic data sources for the development of this dataset are shown in Table 2.

Table 1 Metadata summary of the boundary dataset of built-up areas

Items	description
Dataset full name	Boundary dataset of built-up areas in Chengdu-Chongqing urban economic circle based on POI&ISA composite index (2010, 2020)
Dataset short name	ChengYuUrbanArea_2010_2020
Authors	Zhu, Y. L., College of Tourism and Urban-Rural Planning, Chengdu University of Technology and Key Laboratory of Digital Drafting and Land Information Application, Ministry of Natural Resources, 2597248446@qq.com Zhang, Y., College of Tourism and Urban-Rural Planning, Chengdu University of Technology and Key Laboratory of Digital Drafting and Land Information Application, Ministry of Natural Resources and College of Architecture, Southeast University, zhangyang2020 @ cdut.edu.cn Yang, R. Z., College of Tourism and Urban-Rural Planning, Chengdu University of Technology, 2289533471@qq.com AShuo, A.Y., College of Tourism and Urban-Rural Planning, Chengdu University of Technology, 2816111831@qq.com NaiGuMe, E.W., College of Tourism and Urban-Rural Planning, Chengdu University of Technology, 2139369534@qq.com
Geographical region	There are 16 prefecture-level and above cities in Chengdu-Chongqing economic circle: Chongqing municipality (municipality directly under the Central Government), Chengdu (sub-provincial city) in Sichuan province, Zigong, Luzhou, Deyang, Mianyang, Suining, Neijiang, Leshan, Nanchong, Meishan, Yibin, Guang'an, Dazhou, Ya'an, Ziyang (prefecture-level city)
Year	2010, 2020
Spatial resolution	30 m Data format .shp, .xls
Data size	974 KB (611 KB after compression)
Data files	The statistical data of the boundary and area of the built-up area of 16 cities (2010, 2010) are 32 spatial data files and 1 statistical table respectively
Foundation	Ministry of Natural Resources of P. R. China (ZRZYBWD202201)
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 per cent 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[13]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

3.2 Methods

The built-up area extraction method proposed by Zhang *et al*[11] is centered on the construction of the POI&ISA index. This index is calculated using the following formula:

$$POIISA = \sqrt{POI \times ISA} \tag{1}$$

where, *POI* represents the POI kernel density estimate, and *ISA* stands for the impervious surface index.

The POI kernel density estimation is mainly based on the regular region with a certain bandwidth around any given point in the region as the calculation range for density analysis. Weights are assigned based on the distance from the center point, with closer distances carrying higher weights. The estimated density for each point is the weighted density of all points in the region[16]. The calculation equation is as follows:

$$P_i = \frac{1}{n\pi R^2} \times \sum_{j=1}^{n} \left[K_j \left(1 - \frac{D_{ij}^2}{R^2} \right)^2 \right] \tag{2}$$

Table 2 Introduction of data sources

Data name	Band	Range	Year	Source
Landsat5 TM Image	band2, band5	path: 127–130 row: 38–40	2010	www.gscloud.cn
Landsat8 OLI Image	band3, band6		2020	
Electronic map of the points of interest			2010/2020	Baidu Map
A standardized dataset of built-up areas of China's cities with populations over 300,000 for the period 1990–2015[14]			2010	Science Data Bank
Dataset of the built-up areas of Chinese cities in 2020[15]			2020	*Scientific Data of China*

where, P_i is the kernel density of any point i in the region; K_j is the weight of the study subject j; D_{ij} is the Euclidean distance between point i and the study subject j; R is the bandwidth ($D_{ij}<R$); n is the number of study subjects j within the bandwidth range.

On the basis of Ridd's[17] V-I-S (Vegetation-Impervious surface-Soil) model, where the urban land cover is a combination of vegetation, impervious surface and soil. The proportion of impervious surface, that is, the impervious surface index, can be obtained by adding the abundance of high and low illumination obtained after the decomposition of the linear spectral mixing model[18]. The equation for this is:

$$R_j = \sum_{i=1}^{N} f_i R_{i,j} + e_j \tag{3}$$

where, R_j is the spectral reflectance of band j; N is the number of endmembers; f_i is the proportional weight of endmember i in the pixels; $R_{i,j}$ is the reflectivity of endmember i in band j; e_j is the unmodelled residual error values.

3.3 Technical Route

The data development process in this study (Figure 1) mainly includes four steps: impervious surface index extraction, POI kernel density estimation, POI&ISA index calculation and optimal threshold selection, and post-processing.

3.3.1 Extraction of Impervious Surface

First, Landsat TM/OLI images underwent preprocessing, including radiation calibration and atmospheric calibration. Image registration was conducted based on the 2020 OLI images. Then, through the calculation of the modified normalized difference water index (MNDWI)[19], water masks were generated from the images. Finally, the influence after the water mask was separated by minimum noise, and four pure endmembers (high illumination, low illumination, vegetation and bare soil) were extracted based on the scatter plot. After the linear spectral mixing decomposition, the abundance of high and low illumination was added to obtain the impervious surface index.

3.3.2 POI Kernel Density Estimation

The full-category POI data was filtered based on the definition of built-up areas, retaining only the POI categories related to municipal utilities and public utility coverage. Since the service radius of such utilities and facilities typically fall between 500 m and 1,000 m, a bandwidth of 800 m was selected for the kernel density estimation in this dataset.

3.3.3 Calculation of POI&ISA Index and the Best Threshold

The POI kernel density and impervious surface index were geometrically averaged to calculate the POI&ISA index. The Densi-graph method[6] was then applied to select the optimal threshold for the identification of built-up areas and the extraction of the initial range of the built-up area.

3.3.4 Data Processing

Referring to the post-processing method outlined in the Regulations for Urban Area Scope, the independent map spots with a distance from the built-up area were removed, and the adjacent map spot areas were considered for removal if their area was less than 0.2 km^2. Independent map spots with a distance of less than 100 m from the built-up area were also excluded. To ensure continuity in built-up areas, any inner pores (mainly water, green space, etc.) in the initial boundaries of the built-up area were filled in.

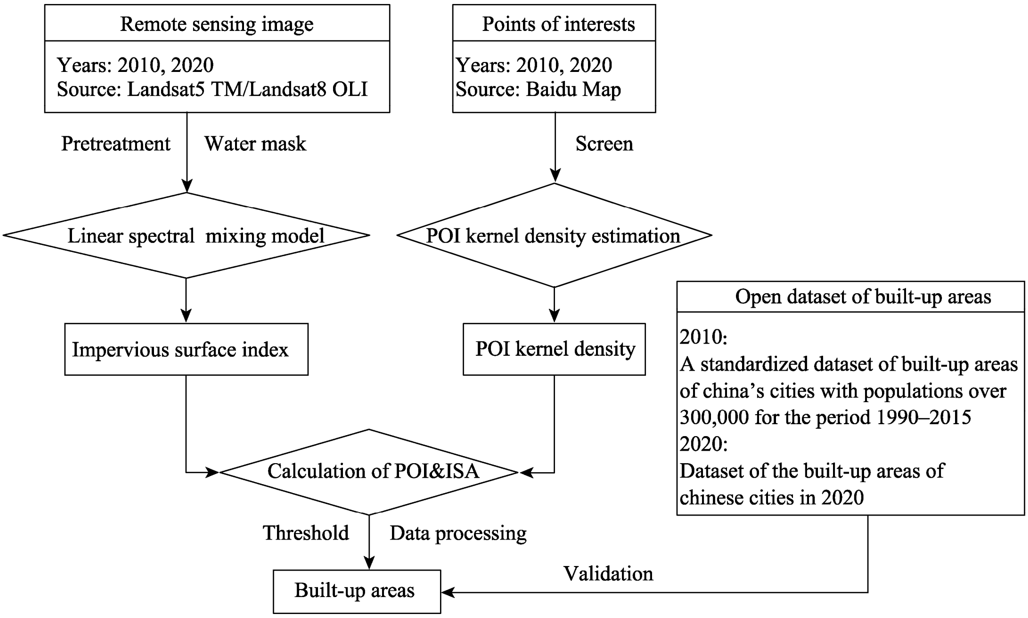


Figure 1 Technical route of the dataset develpoment

4 Data Results and Validation

4.1 Data Composition

This dataset consists of two sets of data items:

(1) The boundaries of the built-up area of 16 cities (2010, 2020) in the Chengdu- Chongqing economic circle. This includes 32 data files in the format of shape-file, with the coordinate system being the Albers equal cone projection.

(2) A statistical table of the area of 16 cities (2010, 2020) in the format of table.

4.2 Data Products

As shown in Figure 2, Chengdu and Chongqing dominate in terms of the area and scale of the built-up area, with a considerable gap compared to the other 14 prefecture-level cities, among which Mianyang, Deyang and Nanchong are the leading built-up areas, while Ya'an has the smallest built-up area. From 2010 to 2020, the absolute increment of the built-up area of Chengdu and Chongqing is significantly higher than that of the other 14 prefecture-level cities, reaching 617.97 km^2 and 359.7 km^2, respectively. Following closely is Mianyang city, with an increase in area of 120.18 km^2; the built-up area of other cities is

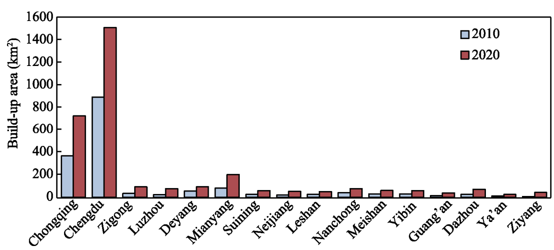
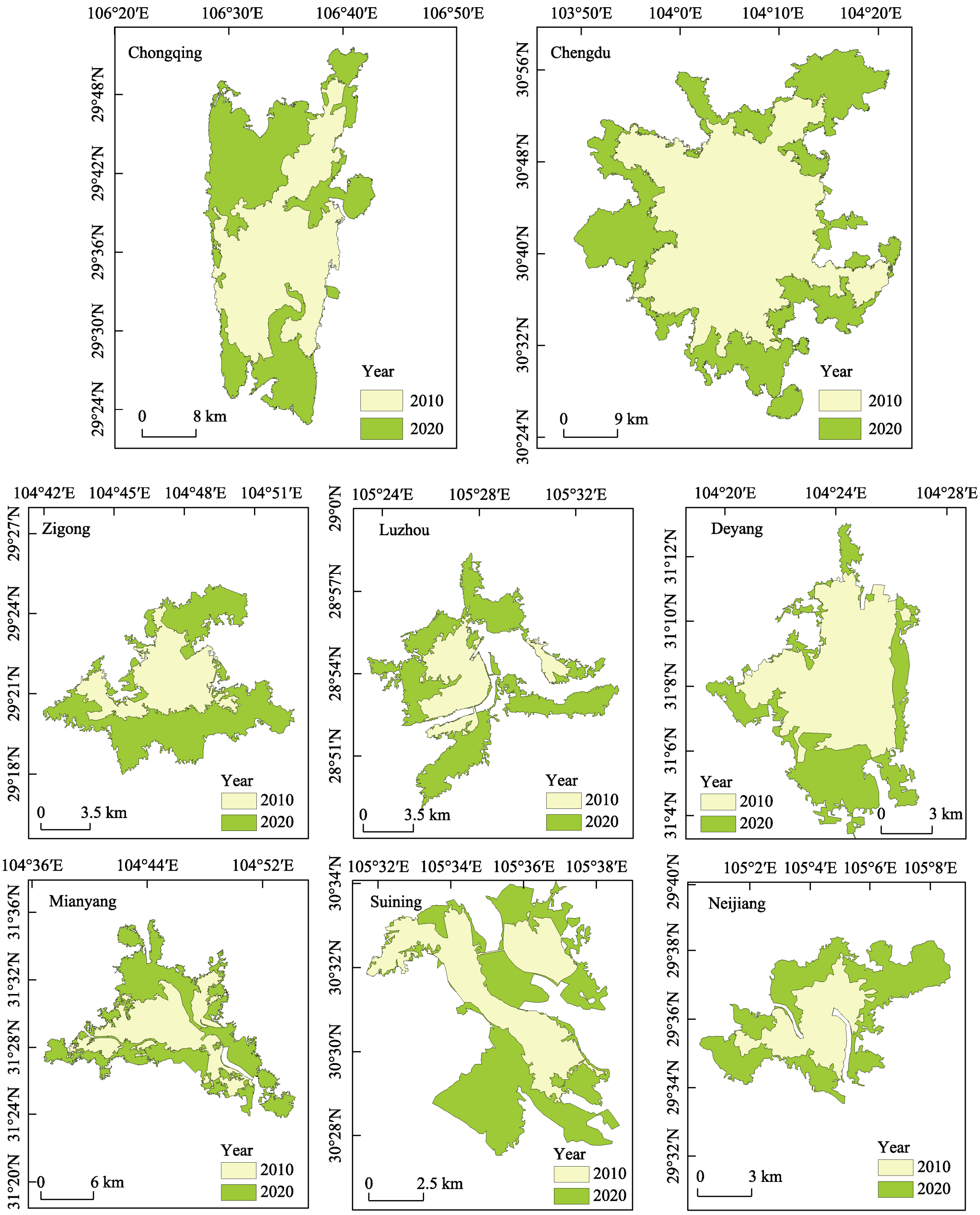


Figure 2 The built-up areas of the Chengdu-Chongqing economic circle

under 100 km^2. In terms of the growth rate of urban built-up area, Ziyang exhibits the highest annual growth rate of 49%; only Chengdu, Deyang, Nanchong, and Leshan have growth rates below 10%; for the rest of the cities, the annual growth rate of built-up area ranges from 10% to 20%.

Due to the different spatial structure types and development conditions of the 16 cities in the Chengdu-Chongqing economic circle, their urban expansion types from 2010 to 2020 also show significant differences (Figure 3). According to the urban expansion classification rules proposed by Wilson and others[20], the 16 cities in the Chengdu-Chongqing economic circle cover five expansion types: marginal expansion, linear expansion, filling expansion, enclave expansion and mixed expansion mode. Chengdu and Deyang, located in the vast Chengdu Plain, exhibit a typical marginal expansion mode for their built-up areas; the built-up



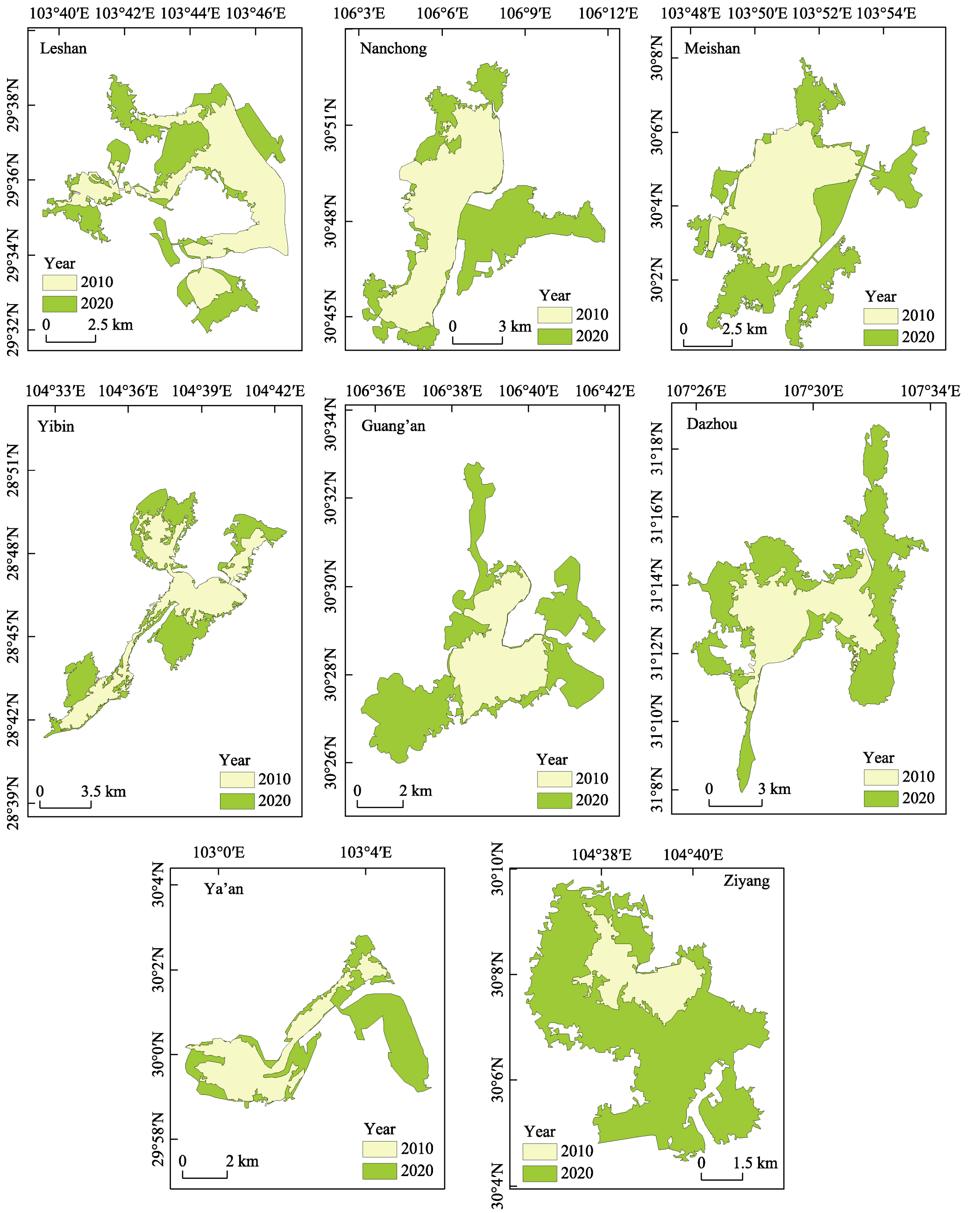


Figure 3 Maps of built-up area of Chengdu-Chongqing economic circle

areas of Yibin, Guang'an and Ya'an show a linear expansion mode along main roads and rivers; in most other cities, various expansion modes are mixed, with Chongqing city and Meishan city demonstrating enclaves into built-up areas based on marginal expansion.

4.3 Data Validation

The built-up areas of 16 cities in the Chengdu Chongqing economic circle for 2010 and 2020 were verified and compared with the respective reference built-up areas. It was observed that there was consistency in the center and form of the built-up area. The correlation coefficient between the urban built-up area and the reference built-up area in 2010 and 2020 reached 0.96 and 0.98, respectively.

The image verification of the experimental results of the built-up area was found between the size and continuity of the dataset and the reference dataset. First, the reference dataset uses the impervious surface as the indicator of urban built-up area, whereas the POI&ISA index also considers the facility POI kernel density index, which leads to the classification of some areas with low impervious surface index but high POI kernel density as the built-up area; according to the requirements of the urban built-up area, the green space, water body, etc. should also be included within the contiguous construction land, which is often surrounded by the POI&ISA index and the urban built-up area.

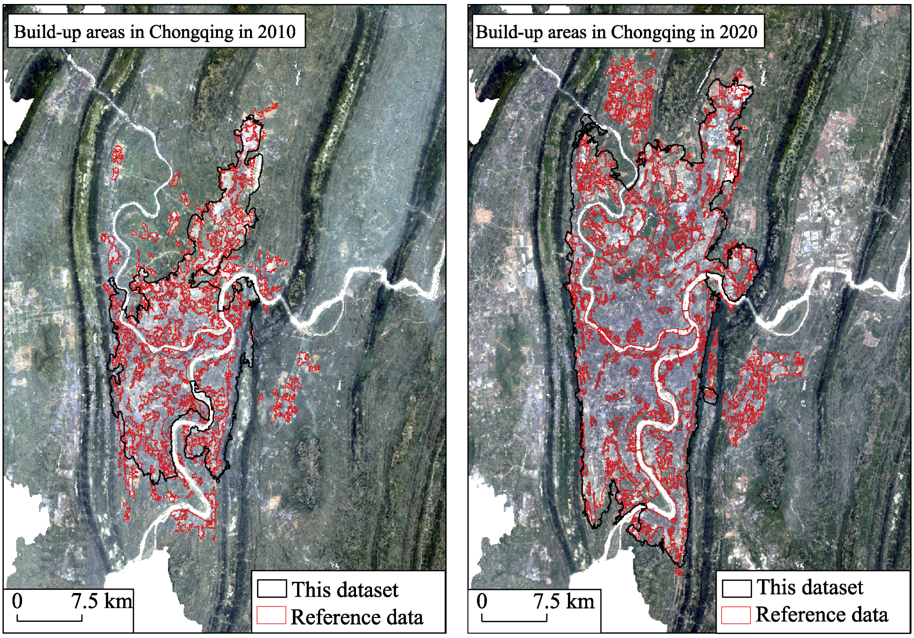


Figure 4 Maps of verification of extraction results in built-up area (Chongqing)

5 Discussion and Conclusion

This dataset extracted the POI&ISA index to obtain built-up areas in both 2010 and 2020, which surpassed the validation dataset in terms of accuracy. The study verifies the applicability of the extraction method based on POI and impervious surface index for the extraction of built-up areas in cities of varying sizes. This contribution extends to the broader application of the POI&ISA index. This method considers the contiguity of urban construction land and the completeness of municipal public and public facilities, which provides a comprehensive representation of the landscape and functional characteristics of urban built-up areas. Furthermore, the operational steps are simpler compared to those outlined in the Regulations for Determination of Urban Scope. The data sources used are readily accessible and undergo dynamic updates. It is worth noting that the POI&ISA index not only enables the extraction of built-up areas through threshold selection to study the urban size and form but also reflects the construction level of these areas through its absolute value, which proves helpful for related research on the expansion of built-up areas from the perspective of scale and efficiency.

Author Contributions

Zhang, Y. designed the algorithms of dataset. Zhu, Y. L., Yang, R. Z. and AShuo, A. Y. contributed to the data processing and analysis. NaiGuMe, E. W. and Yang, R. Z. did the data verification. Zhu, Y. L. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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