

# RESEARCH ON VALIDITY MEASUREMENT OF MEGACITIES RENEWAL POLICIES AND SUITABILITY SCALE FOR URBAN REMOTE SENSING DATA APPLICATIONS: TAKING BEIJING'S DUAL CONTROL POLICY AS AN EXAMPLE

Wu Ying<sup>1,3</sup>, Li Aiqun<sup>2,3</sup> \*

<sup>1</sup> School of Science, Beijing University of Civil Engineering and Architecture, No. 1 Exhibition Hall Road, Beijing, wuying@bucea.edu.cn

<sup>2</sup> School of Civil and Transportation Engineering, Beijing University of Civil Engineering and Architecture, No. 1 Exhibition Hall Road, Beijing, liaiqun@bucea.edu.cn

<sup>3</sup> Beijing Key Laboratory of Functional Materials for Building Structure and Environment Remediation, Beijing University of Civil Engineering and Architecture, No. 1 Exhibition Hall Road, Beijing

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## ABSTRACT:

Urban renewal has become the application hotspot of urban remote sensing development in recent years. However, scientific distribution of weight relationship between indicators reflecting progress and effectiveness of different urban renewal goals and tasks, and comprehensive evaluation of effectiveness of policies in the existing indicator system require further in-depth research. In particular, there is no clear standard for application caliber of remote sensing data of different cities in spatial indicators. Taking Beijing's dual control policy as an example, this paper measures effectiveness of mega-city renewal policies represented by Beijing based on analytic hierarchy process, and analyzes types of remote sensing data suitable for urban renewal. In addition, the suitability scale of urban remote sensing data application is given through case studies. By analyzing the actual validity of Beijing's dual-control policy implementation, it is concluded that the application scale of urban remote sensing data for urban renewal suitability is remote sensing image big data > remote sensing data artificial intelligence algorithm > remote sensing image historical data > remote sensing big data. It is necessary to focus on automatic identification and exploration of spatial changes based on remote sensing, design and calculation of spatial indicators of urban physical examination based on remote sensing in the future. Furthermore, work needs to be carried out to further improve evaluability, accuracy and objectivity of practical application of remote sensing data in different cities for urban renewal, and explore establishment of a clear urban physical examination system and remote sensing data application system guidelines.

## 1. INTRODUCTION

The purpose of public policy evaluation is to examine the effectiveness of public policies, to rationally allocate policy resources, and to improve the scientific nature of public policies (CHEN Zhenming, 2003). Spatial policy zoning has become the mainstream way for western developed countries (regions) to implement strategic spatial layout and differentiated policy supply. For example, the "America 2050" space strategic plan is the result of overall consideration based on the country's multiple strategic goals. The plan clarifies five strategic goals and points out policy directions for different goals. The development vision and actual situation dynamically adjust the spatial policy division. The latest "New National Spatial Strategy" highlights the functional positioning and policy orientation of the eight regions. Germany has compiled the Metropolitan Area Planning, which emphasizes differentiated development according to the level and potential of regional economic development, and proposes different development strategies for metropolitan areas, agricultural areas, and old industrial areas. In addition, different development strategies are proposed for metropolitan areas, agricultural areas and old industrial areas. The EU region has designed a multi-

dimensional and systematic policy toolkit based on the "EU Standard Geographical Statistical Unit" around the "Europe 2020 Goals". For example, in the Northwest Region (NUTS1), tool kits including infrastructure construction, improvement of government governance capabilities, and improvement of ecological space have been arranged. In order to adapt to the specialization and common goals of the region, each NUTS2 region has carried out more detailed prioritization, task division and policy refinement (WANG Ziyi, ZHANG Jingxiang, LI Di, 2022).

Recent theoretical developments have revealed that China's urban development has been moved into the important period of urban renewal, completing the transformation from large-scale incremental construction to stock quality improvement and incremental structural adjustment. With the continuous introducing and upgrading of a series of urban renewal policy documents promulgated by the State Council, ministries and commissions, urban renewal has been officially risen to the national level strategy. There is evidence that urban physical examination plays a crucial role in implementing urban renewal. Concerning on it, urban physical examination is defined as the

\* Corresponding author

comprehensive evaluation of urban development and construction. And on this basis, targeted countermeasures are formulated. Urban physical examination is of great significance, which could be reflected in two aspects: it is interpreted to be the essential work to solve the current problem of “urban diseases”; furthermore, it is considered to be a critical starting point, which plays an important role in implementing urban renewal operation and promoting the high-quality development of urban human settlement environment.

The source of urban physical examination data is based on government public data, supplemented by social big data, social perception data, sampling survey data, along with an emphasis on integration of urban remote sensing data. In the urban physical examination index system, the spatial indicators of ecological livability, safety and resilience, convenient transportation, and appearance features are particularly closely related to urban remote sensing data. Specifically, the ecological livability index is mainly based on remote sensing image big data; the safety and resilience index is basically upon artificial intelligence algorithm of remote sensing data; the traffic convenience index is primarily derived from remote sensing big data; the style characteristic index data is principally proceeded from historical remote sensing image data. Remote sensing data of different cities could reveal the causality of different target orientations behind urban renewal. However, there are relatively few studies devoted to scientific distribution of weight relations between indicators reflecting progress and effectiveness of different urban renewal goals and tasks, and issue of efficacy of comprehensive policies evaluation of existing indicator system. Especially, application caliber of remote sensing data of different cities in the spatial indicators has yet to be clearly defined. Therefore, the ultimate goal of this paper is suitability scale for applications of remote sensing data in different cities under the urban physical examination space index, which oriented to evaluation of urban renewal policies performances in different dimensions. The investigation on such potentials is supposed to be the key role, which presents a wide range of possibilities for the further improvement of evaluability, accuracy and objectivity of spatial indicators in urban physical examination.

## 2. METHODOLOGY

The use of remote sensing technology is capable of evaluating the effect of national policies implementation, such as evaluation of urban reduction development goals, supervision of primary management space, and major special projects (e.g., function transfer and remediation, reconstruction of old residential areas). It fully implements the link between increase and decrease, promotes the reduction and improvement of urban and rural construction land, keeps the strategic blank, and leaves space for future development. Beijing proposed the dual control policy of strict population and construction scale, becoming the first mega city to reduce the amount of development. Analytic hierarchy process method would be used in this part to evaluate progress and effectiveness of the dual control policy, and analyze suitability of different urban remote sensing data scale in the urban physical examination spatial indicators.

### 2.1 Urban Physical Examination Index System

According to the latest 2022 urban physical examination index system released by the Ministry of Housing and Urban-Rural Development, the urban physical examination includes 69 items in 8 aspects including ecological livability, health and comfort,

safety and resilience, convenient transportation, style and features, cleanliness and orderliness, diversity and inclusiveness, and innovation vitality. The indicators with a large proportion are 19 items of ecological livability, 12 items of health and comfort, and 12 items of safety and resilience. It could be closely combined with the actual situation of the physical examination city to appropriately add content and indicators that reflect the quality of human settlements that need to be paid attention to the process of urban renewal, as well as the implementation timing, dynamic guarantees, and multiple co-governance.

### 2.2 Analytic Hierarchy Process

AHP is an analysis method that combines qualitative analysis and quantitative analysis. It was developed by American operations researcher A.L.Saaty to provide a basis for choosing the optimal method. It is suitable for complex fuzzy comprehensive evaluation system and is a widely used method to determine weights at present (WANG Yingluo, 2001). AHP achieves qualitative analysis of non-quantitative event science, while also satisfying precise quantitative analysis.

### 2.3 Indicator Selection

The criterion layer selects ecologically livable, safe and resilient, convenient transportation, and characteristic spaces in urban physical examination index system that are closely related to urban remote sensing data. The criteria layer is set to ecological livability, security resilience, great accessibility and appearance features. The index layer selects regional development intensity, coverage of urban greenway service radius, proportion of ecological land in urban ecological corridors and ecological intervals, proportion of ecological and living coastlines in total coastlines of ecological livability; density of urban road network, the ratio of commuter coverage around the rail site, density of dedicated bike lanes of great accessibility; coverage of urban standard fire stations and small ordinary fire stations, coverage of second-level and above hospitals in cities, 3D data coverage of urban information model (CIM) basic platform construction of security resilience; cultural building area of 10,000 people, historic building vacancy rate, number of negative events that destroy the historical landscape of appearance features. Fully understand the actual demands of people and their satisfaction and dissatisfaction with Beijing’s dual control policy. Evaluating the phased problems existing in urban renewal and formulate problem rectification plans in a targeted manner. Evaluating the performance of urban renewal policy oriented to the dimension of Beijing’s dual control policy and clarifying the appropriate application of remote sensing data scales of different cities in the urban physical examination space index. Specifically, the basic steps of evaluation method include as following: establishing a structural model, establishing a judgment matrix, sorting by single criterion, checking and revising the consistency of the judgment matrix.

## 3. RESULTS AND DISCUSSION

### 3.1 Double Control Policy Case

A series of national policies such as the central conference on urbanization in 2013, the central city work conference in 2015, and the “key construction tasks of new urbanization” announced by National Development and Reform Commission in 2019, clearly put forward the urban renewal and development of “strictly controlling increment and revitalizing stock” guide direction. The “beijing urban master plan (2016-2035)” clearly

puts forward planning guidelines for land use reduction and population reduction, as well as development requirements for organic renewal. It is necessary to reduce the scale of urban and rural construction land, promote the reduction and quality improvement of urban and rural construction land, and the intensive and efficient use of urban and rural construction land. .

Beijing has shifted from aggregating resources for growth to easing non-capital functions for development, becoming the first super-large city in the country to reduce development. The city’s resident population has dropped from a peak of 21.954 million in 2016 to 21.886 million in 2021, with a net reduction of about 110 square kilometers of urban and rural construction land. From urban management to mega-city governance, a profound transformation has been achieved, and new historic changes have taken place. In the past ten years, Beijing’s GDP has increased from 1.9 trillion yuan to 4.03 trillion yuan, and its per capita GDP has increased from 92,800 yuan to 184,000 yuan, ranking first in the country and reaching the level of a moderately developed economy.

According to the stage of the public policy process, public policy assessment could be divided into three types: pre-assessment, in-process assessment and post-assessment; from the perspective of the status of the assessment agency, it could be divided into internal assessment and external assessment; from the perspective of policy impact it could be divided into policy benefit evaluation, policy efficiency evaluation, policy effect evaluation, etc(LIN Shuibo, ZHANG Shixian, 1986). The renovation of old communities is a key link in urban renewal. From the complex logical starting point of Beijing’s old community renovation policy, we could see the particular significance of carrying out research on the effectiveness of Beijing’s urban renewal policy. (See Table 1) The particularity of the background of the construction of Beijing’s urban renewal system is mainly reflected in the constraints of special development requirements such as capital positioning, reduction development, relaxation and renovation, and organic renewal. Compared with other cities, which could stimulate urban renewal power and balance renovation funds by increasing development capacity, Beijing could only implement organic renewal by reducing “quantity” and improving “quality”, so it faces stricter renewal than other cities. Conditions and planning control requirements also bring about a relative lack of incentive mechanisms—this is also the key to Beijing’s special urban renewal environment and relatively small institutional steps. As the capital of the country, and a representative city that implements reduction planning and functional relief, Beijing has not yet made a breakthrough in the construction of urban renewal systems due to its dependence on traditional systems and its need to avoid reform risks(TANG Yan, ZHANG Lu, 2021).

Time	Policy documents	Involving “double aging” content
2016.01	Opinions of the Beijing municipal government on further accelerating the reconstruction of shantytowns and dilapidated houses in urban and rural areas and the	From 2015 to 2017, we will strive to transform a total of 127,000 houses in shanty towns, including urban dilapidated houses and old communities, and 2,600 dilapidated houses in rural areas, so as to effectively improve the living conditions and living environment of the masses.

	construction of supporting infrastructure.	
2018.03	Comprehensive renovation work plan for old communities (2018-2020)	Improve supporting facilities in the old community, make up for shortcomings, optimize functions, improve the environment, solve the most concerned, direct and realistic problems of the masses, and strive to make the old community a comfortable, convenient, clean and orderly living a beautiful home with beautiful environment, harmonious neighbors, and mutual assistance, constantly enhancing residents’ sense of gain, happiness and security.
2021.01	Implementation opinions on deepening and promoting the special action of “relieving, rectifying and promoting improvement” during the “14th Five-Year Plan” period	Focusing on issues such as the renovation of old residential areas, environmental governance, and public service facilities that have been highlighted, a plan for one street and one town, clear governance tasks, based on long-term governance, improve functions, make up for shortcomings, concentrate energy and resources, and crack the grassroots governance problems.
2021.04	Opinions on renovation and renovation of old community	Adhere to the guidance of planning and give priority to people’s livelihood, follow basic work process of comprehensive renovation of old community, focus on the implementation of the “seven haves” and “five characteristics”, ensure safety of residents’ living, make up for the shortcomings of community public services, and improve the comfort and convenience of residents’ lives. In the renovation and reconstruction of old communities, the green area and the number of parking lots shall not be lower than the current status in principle.
2021.05	2021 work plan for comprehensive renovation of old residential areas in Beijing	The renovation of old community is an important task to integrate into the new development pattern. Stimulate the initiative and enthusiasm of residents to participate in the renovation. Give play to the leading role of grassroots party building, integrate community governance capacity building into the transformation process, promote innovation in community governance models, and improve long-term

		community management mechanisms.
2021.05	Guiding opinions of the Beijing municipal people's government on implementing urban renewal actions	Implement comprehensive renovation of old community. According to residents' wishes, the existing houses and public spaces in the community could be used to supplement public service facilities such as convenient commerce and elderly care services; open spaces, demolition of illegally vacated land could be used to increase parking spaces, or to set up mechanical parking facilities and other convenience facilities. Encourage old residential buildings to install elevators.
2021.05	Guiding opinions on comprehensive renovation of old residential areas, implementing age-appropriate transformation and construction of barrier-free environments	During the "14th Five-Year Plan" period, for the old community that have been comprehensively renovated, according to local conditions, the content of suitable aging renovation and barrier-free environment construction would be clarified one by one, so as to achieve barrier-free access; support for existing multi-storey residences with conditions to install elevators and make rational use of space improve elderly care service facilities, guide elderly families in need to carry out home-based aging transformation; promote and support property service enterprises, elderly care service institutions to provide elderly care services, effectively increase the effective supply of home-based elderly care services, and effectively meet the elderly's home-based elderly care needs.
2021.08	Comprehensive renovation standards and technical guidelines for old residential areas in Beijing	Combined with the comprehensive renovation of old community, we should coordinate and promote the simultaneous implementation of home-based aging-appropriate renovation for eligible elderly with special difficulties and disabled families. Combining home-based aging-friendly transformation with informatization and intelligent home-based community pension services, information systems such as family help for the elderly and calling for help can be set up according to residents' wishes.
2021.08	The renovation plan of old	Focus on aging-friendly renovation, promote the

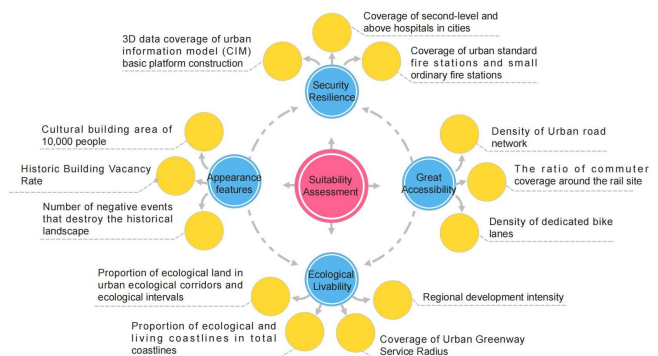
residential areas in Beijing during the "14th Five-Year Plan" period	construction of an aging-friendly and barrier-free public environment, support the installation of elevators in old buildings with conditions, explore the use of market-oriented mechanisms, introduce third-party institutions to build and operate elderly care service facilities, and encourage professional enterprises to participate in home adaptation according to the needs of residents aging renovation, encourage "property service + senior care service", and improve the living and living convenience of the elderly.
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**Table 1.** Sorting out the policy evolution of old residential areas in Beijing.

### 3.2 Analytic Hierarchy Process

#### 3.2.1 Establishing a structural model for applying AHP:

Figure 1 illustrates the content of the evaluation method indicators, which are divided into target layer, criterion layer and indicator layer.



**Figure 1.** Hierarchical schematic map of evaluation index.

#### 3.2.2 Establishing a judgment matrix for applying AHP:

In order to compare the influence of each factor in the criterion layer on the target layer and each factor in the index layer on the criterion layer, the factors in the layer are compared in pairs, the weight of each element is obtained, and the judgment matrix  $C = (C_{ij})_{n \times n}$  is determined. In this paper, the analytic hierarchy process uses a scale of 1 to 9 to express the degree of importance. The assignment of importance  $C_{ij}$  is at the discretion of experts, scholars or consultants to reduce bias in subjective aspects.

The writing matrix form is:

$$C = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} \\ C_{21} & C_{22} & C_{23} & C_{24} \\ C_{31} & C_{32} & C_{33} & C_{34} \\ C_{41} & C_{42} & C_{43} & C_{44} \end{bmatrix} \quad (1)$$

**3.2.3 Applying Analytic Hierarchy Process for Single Criterion Sorting:** Rank the spatial indicators of ecological livability, safety and resilience, convenient transportation, and features in the urban physical examination index system

(1) Normalize the elements of the judgment matrix by column.

$$C_{ij} = \frac{C_{ij}}{\sum_1^n C_{ij}} \quad (i,j=1, 2\dots n) \quad (2)$$

(2) The resulting elements in C are added row by row:

$$W_i = \sum_1^n b_{ij} \quad (i,j=1, 2\dots n) \quad (3)$$

(3) Normalize the resulting vector:

$$W_i = \frac{W_i}{\sum_{i=1}^n W_i} \quad (i,j=1, 2\dots n) \quad (4)$$

The obtained is the approximate solution of the eigenvector  $W = (W_1, W_2, W_3, \dots, W_n)^T$

For any  $i=1, 2, \dots, n$ ,  $(BW)_i$  is the  $i$  element of vector BW.

Through the formula(1)~(4), the following results could be obtained in this case:

$$C = \begin{bmatrix} 1 & 1/2 & 1/2 & 1/8 \\ 2 & 1 & 3 & 1/4 \\ 2 & 1/3 & 1 & 0.2 \\ 8 & 4 & 5 & 1 \end{bmatrix}$$

the W of great accessibility, security resilience, appearance features, ecological livability are obtained as  $W=(0.073658505, 0.199948589, 0.110809074, 0.615583831)$ .

**3.2.4 Checking and Correcting the Consistency of Judgment Matrix:** In the actual comparative judgment, due to the difference of human subjective judgment and the complexity of objective things, it is necessary to check and correct the consistency of the judgment matrix. Specific steps are as follows:

(1) Calculating the deviation consistency index CI

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (5)$$

where  $n$  = The dimension of the judgment matrix  
 $\lambda_{\max}$  = Largest eigenvalue

(2) Calculating the average consistency index RI. The average consistency index, that is, the deviation consistency index of the random judgment matrix of the same order, is obtained by the mathematical statistics method(LIU Bao, XU Shubai, ZHAO Huanchen, HE Jinsheng, 1984).

(3) Calculate the relative consistency index CR

$$CR = \frac{CI}{RI} \quad (6)$$

The calculated CR value must meet  $CR \leq 0.1$ , and the smaller the CR value, the higher the consistency of the judgment matrix; if  $CR > 0.1$ , it needs to be re-corrected until it meets the requirements.

Through the formula(5)~(6), The result of this case study is as follows:

$$\begin{aligned} CI &= 0.043472489 \\ RI &= 0.9 \\ CR &= 0.048302765 \end{aligned}$$

$CR \leq 0.1$ , meet the requirements. Therefore, according to the above analysis of the four spatial indicators in the urban physical examination index system, the W of great accessibility, security resilience, appearance features, ecological livability are obtained as  $W=(0.073658505, 0.199948589, 0.110809074, 0.615583831)$ . The application scale of urban renewal suitability of urban remote sensing data is remote sensing image big data > remote sensing data artificial intelligence algorithm > remote sensing image historical data > remote sensing big data.

Through the above analysis, this paper could evaluate typical representative of megacities and actual effectiveness of Beijing's dual-control policy implementation. Meanwhile, suitability scale of urban remote sensing data applications under such urban renewal policy assessment could be further obtained. Thus, urban spatial structure and functional layout of Beijing could be adjusted and optimized from the larger urban remote sensing data space, along with the in-depth treatment of urban diseases.

Non-professionals often encounter confusion in the selection of data source scales in remote sensing image applications(Han Peng, Gong Jianya, Li Zhilin, BO Yanchen, CHENG Liang, 2010). Remote sensing workers who study urban renewal need to understand certain business work and understand the industry standard requirements of remote sensing photogrammetry, such as the survey of data in the survey work of the reconstruction area, which includes basic surveying and mapping geographic information data (topographic map, reconstruction Area tilt photogrammetry data, DOM image data, elevation laser scanning data, aerial single-point panorama, other image data, etc.). Through the verification of basic data, the building volume, the detailed construction area and floor area of the reconstruction area could be accurately calculated. For another example, in the evaluation of renovated area, the land development intensity is evaluated, which directly affects the estimation of land price; in general, the higher the land development intensity, the higher the economic benefits of land use, including plot ratio, building density, building height, green space rate and other major indicators could be extracted from remote sensing images by certain methods (PAN Zhuokun, HU Yueming, WANG Guangxing, LIU Houhai, LIU Jiang, LI Bo, FAN Shudi, 2020).

#### 4. CONCLUSION

Based on the background of Beijing's dual control policy, this study uses the remote sensing-based spatial index system in urban physical examination to analyze the actual effect of urban renewal policies. It provides a theoretical basis for the similarities and differences, application and organic integration of multi-source urban remote sensing data in urban physical examination research, and makes the evaluation results of urban renewal policies performances more comprehensive and scientific. In addition, thinking from the perspective of urban

remote sensing data applications, it provides ideas and suggestions for the further improvement and development of urban physical examination index system research and urban renewal policies practices.

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Under the multiple challenges of dual control of population scale and construction scale, industrial structure transformation and upgrading, and urban function optimization and adjustment in the new era, the application of remote sensing in urban renewal needs to solve some common problems in industrial applications, such as land change total element map extraction, remote sensing identification of inefficient construction land, accurate estimation of building footprint, etc. Besides, the application of remote sensing in urban renewal should also focus on the needs of planning implementation and urban physical examination, such as the automatic identification and exploration of spatial changes based on remote sensing, and the design and calculation of spatial indicators of urban physical examination based on remote sensing. In addition, some work is still needed to further improve the evaluability, accuracy and objectivity of the practical application of remote sensing data in different cities for urban renewal, and explore the establishment of a clear urban physical examination system and remote sensing data application system guidelines. The coming normalized urban renewal work should be handled scientifically to make cities smarter and smarter, so as to jointly promote the orderly development of urban renewal practices.

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