Urban Human Settlement Environment Suitability Assessment—A Case Study of Beijing

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Abstract. In this study, an index system for evaluating the suitability of urban human settlements was established by analytic hierarchy process (AHP). According to the single index score of information entropy standardized scaling treatment, the suitability of human settlements in Beijing from 2004 to 2017 was comprehensively evaluated. The results show that the suitability of human settlements in Beijing is obviously improved, and the suitability of resources and environment has experienced significant fluctuations, which is different from the trend of sustainable growth of economic and social habitability. The purpose of this study is to improve the understanding of the historical changes and future development trends of the human settlements environment in Beijing, and to further promote the construction of the human settlements environment in the capital and the continuous improvement of the quality of life of the citizens.

Introduction

Human settlement environment is the basis of human survival and development. Its quality is not only directly related to human physical and mental health, but also a issue of population, society, environment and resources coordination. It is also an important symbol to measure the progress of human society and the development of culture[1]. Urban human settlements environment is a comprehensive concept, it not only refers to the physical space of human habitation and activities, but also includes the population, resources, environment, social policy and economic development[2]. The evaluation of the suitability of human settlements is an important part of the study of urban human settlements, which reflects the situation and development of urban human settlements through the establishment of relevant index system and the process of statistical analysis.

Beijing, as the capital of China, is also a typical representative of metropolis. With the rapid development of economy since the reform and opening up, great changes have taken place in all aspects of social environment. Beijing is chosen as the research area to evaluate the suitability of urban human settlement environment, which provides a basis for decision-making on the construction and management of urban human settlement environment. It is conducive to the further development of the human settlements environment in Beijing and the practical gains in the quality of life and social well-being of the citizens.

Data and Method

Data Sources

The data were obtained from the Beijing Statistical Yearbook 2005-2018, the Beijing Environmental status Bulletin 2004-2017, and some of the data from the National data website.

Establishment of Index System

In this study, AHP was used to construct the evaluation index system of urban human settlements suitability. From the aspects of economic suitability, social habitat suitability and resource and...
environmental suitability, the criteria for evaluating the suitability of urban human settlements in Beijing are constructed.

Economic suitability reflects the supporting role of social and economic conditions on human settlements, mainly by considering the wealth distribution equality index and correcting the per capita GDP after inflation. The suitability of social settlements can be divided into four sub-criteria: living conditions, urban construction and management, social security and welfare, and comprehensive competition intensity. The suitability of resource and environment is mainly reflected by water resources condition, water environment condition, atmosphere environment quality and sound environment condition. A total of 24 evaluation indicators were selected, among which those with high linear correlation were dealt with in the Analytical hierarchy process (AHP).

Table 1. Indicator and evaluation criterion weight system of human settlement environment suitability in Beijing.

| Criterion layer                          | Sub-criteria layer                     | Evaluating indicator                                                                 |
|------------------------------------------|----------------------------------------|---------------------------------------------------------------------------------------|
| Economic suitability (0.0890)            | Socioeconomic status (1)               | Corrected GDP per capita (1)                                                          |
|                                          | Housing conditions (0.2439)             | Urban housing area per capita (0.75)                                                  |
|                                          |                                        | Green space area per capita (0.25)                                                    |
|                                          | Urban construction and management (0.1650) | Public toilets per 10,000 people (0.2385)                                             |
|                                          |                                        | Number of rail transit operations per 10,000 population (0.1563)                        |
| Social habitat suitability (0.5876)      |                                        | Public transport vehicles per 10,000 people (0.1563)                                   |
|                                          |                                        | Taxi ownership per 10,000 people (0.1562)                                             |
|                                          |                                        | Urban road area per capita (0.1562)                                                   |
|                                          |                                        | Proportion of direct property loss in traffic accidents (0.1365)                      |
|                                          | Social security and well-being (0.4953) | Proportion of urban basic medical insurance (0.2814)                                  |
|                                          |                                        | Proportion of active workers participating in old-age insurance (0.2814)               |
|                                          |                                        | Number of practising (assistant) doctors per 10,000 population (0.1407)                |
|                                          |                                        | Number of health technicians per 10,000 population (0.1407)                            |
|                                          |                                        | Proportion of education expenditure (0.1558)                                          |
|                                          | Comprehensive competition intensity (0.0958) | Urban population density (1)                                                       |
| Resource and environment suitability (0.3234) | Water resources condition (0.4034)    | Per capita water resources (0.8)                                                     |
|                                          |                                        | Percentage of reservoir capacity up to standard (0.2)                                 |
|                                          |                                        | Percentage of river length up to standard (0.25)                                      |
|                                          | Water environment state (0.1475)        | Lake capacity / area percentage up to standard (0.25)                                 |
|                                          |                                        | Percentage of length of river substandard V-type (0.25)                               |
|                                          | Atmospheric environmental quality (0.2949) | Percentage of area of lake substandard V-type (0.25)                                |
|                                          | Sound environment condition (0.1542)    | Days with Air quality better than second grade (0.75)                                 |
|                                          |                                        | Heavy pollution days (0.25)                                                          |
|                                          |                                        | Urban area noise (1)                                                                 |

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Research Technique

This study attempts to score each single index without a quantitative standard system or grading criteria. In the period of 2004-2017, the values of each single index were standardized. The original score of each single index was about 0, and the standard deviation was about 1. Since then, the original score can be standardized and scaled by using the idea of entropy weight method, which can reflect the true change range and the change ratio of each single index in 2004-2017.

Entropy weight method is a common objective assignment method, which avoids the defects of the subjective assignment method such as Delphi method and expert ranking method to some extent. For a certain index, the greater the information entropy value, the greater the variation of the index value, then the greater the role of the index in the evaluation analysis \[^{[3]}\]. In this study, the entropy weight method is not combined with the subjective weight determination method such as Analytic hierarchy process (AHP), but through the information entropy of each single index data, the score of each single index is obtained without quantitative evaluation criteria.

According to the calculated scores of each index and the weight of each index, the index integration is carried out, and the comprehensive scores of each criterion layer, sub-criterion layer and the whole population of the suitability of human settlement environment in Beijing from 2004 to 2017 are obtained. When the score $\geq 0$, the more positive the score, the better the suitability, and when the score $\leq 0$, the more negative the score, the worse the suitability.

Results

Figure 1. Inter annual variation of human settlement environment suitability in Beijing.

Figure 1 shows the change of urban habitat suitability in Beijing from 2004-2017. An upward trend in overall scores can be observed, but there was no significant increase in 2008-2015. Beijing's economic suitability shows a marked upward trend, however, it can be observed that there was a significant decline in 2014-2015, mainly due to the sharp rise in the wealth distribution inequality index, which may be related to the change in statistical caliber. Compared with the other two kinds of suitability, the social habitability of Beijing is increasing steadily, and the range of change is relatively small. Interestingly, the suitability of resources and environment in Beijing has experienced a cycle of fluctuations. In fact, in addition to the changes in the resource environment itself, it also comes from changes in statistical methods, procedures, and management.

Figure 2 shows the track of urban habitat suitability in Beijing from 2004 to 2017. In the two dimensional coordinate system of society and nature, the suitability of economic and social
settlements and the suitability of natural resources and environment in Beijing between 2004 and 2008 continued to improve. In 2008-2014, the suitability of economic and social human settlements continued to improve, however, Natural resources and environmental suitability declined significantly. In the above two stages, the trajectory of habitat suitability in two dimensional coordinate system can be fitted into straight line segment. Beginning in 2015, both types of suitability began to show an upward trend.

Figure 2. Coordinate track of human settlement environment suitability in Beijing, 2004-2017.

Figure 3. Inter-annual variation of Social Habitat suitability Index and Resource and Environmental suitability Index.

Figure 3 dissects four sub-criteria of social habitat suitability evaluation and four sub-criteria of resource and environment suitability evaluation in Beijing area. From 2004 to 2017, the scores of living conditions, urban construction and social security increased significantly, and the comprehensive competitive pressure increased continuously, but slowed down and tended to stagnate in recent years.

The change of comprehensive index of resources and environment in Beijing is more complex. The sound quality of the environment remains stable and almost unchanged. The conditions of water resources and the conditions of water environment, the quality of atmospheric environment
and the suitability of resources and environment all have obvious similar periodic fluctuations. Overall, it reached a peak in 2010 and a trough in 2014.

**Discussion and Conclusion**

In this study, a self-constructed index system was used to evaluate the suitability of urban human settlements in Beijing from 2004 to 2017. In general, the suitability of human settlements in Beijing has been improved significantly during the period of study. When it comes to comprehensive scoring at the criterion level, it has a very different pattern of change, which, in the final analysis, is influenced by different driving forces and paradigm changes.

It is worth noting that the conclusion of this study is based on official statistics. Therefore, some anomalies were found in the process of data processing by the author. For example, the issue of haze in Beijing has been a concern since 2009, but it was not until 2013 that Beijing had a comprehensive PM2.5 monitoring system. Air quality statistics for previous years (especially days of heavy air pollution) are likely to have significant deviations.

The urban human settlement environment is affected by many factors and has multiple complexity. This paper only constructs the index system from the aspects of economy, social settlement, resources and environment, and does not select and analyze the index on a larger scale. The future research needs to further refine and construct a more perfect evaluation index system. In addition, the study of this paper does not analyze the relationship between the indicators, mainly from the macro point of view of the index system construction and suitability evaluation, at present, at the micro level, the effect and process of specific factors affecting human settlement environment need to be further studied.

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