Research on the Measurement of New Urbanization Level in Anhui Province from the Green Perspective

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Abstract. With the continuous deepening of the new urbanization process, some contradictions in its development process become increasingly obvious, among which the environmental problems are particularly prominent. People's demands for green residential towns are further raised, and the concepts of ecological city, green town and sustainable development society are put forward. In this paper, new urbanization and "green" are linked to determine the concept and connotation of green new urbanization. Under the core connotation of the green perspective, the level of new urbanization in Anhui Province is analyzed from four levels of green economy, green environment, green living and green foundation, thus promote the healthy and benign development of new urbanization and provide an opportunity to improve the mechanism of regional ecological coordinated development.

1. Introduction
The word "urbanization" originated from "Basic Theory of Urbanization", which was used to describe European Urbanization under the first industrial revolution[1]. During this period, urban development was mainly focused on the urbanization of resources, which led to serious environmental problems in cities and towns. These problems mainly manifested as heavy and light industrial pollution, ecological damage and backward urban infrastructure. After the end of World War II, countries ushered in the opportunity of stable development, and urbanization in various regions stepped into the stage of rapid improvement. At this time, although people paid some attention to green urbanization, they still did not associate the problem of green development with blind urban development[2]. Since the middle and late 20th century, developing countries have become the mainstay of urbanization development. However, due to insufficient understanding of development mechanism and blind pursuit of economic increment, urban development is too concentrated[3]. Therefore, sustainable, green and people-oriented will become the main concept of urbanization in the future. With the change of environment at home and abroad, China is in the stage of rapid urbanization and industrialization, "green coordinated and sustainable" has become a new green urbanization development model in China[4]. Compared with previous urbanization, the green new urbanization emphasizes more on quality, pursuing green development and balance development of urban and rural areas. Anhui province is the mainstay of the development of the Yangtze River Delta and the central region, it has obvious regional advantages. The development of new urbanization in Anhui Province plays an important role in the development of China's new urbanization.
According to the current research on new urbanization, there are many definitions. For example, some people think that it is different from traditional urbanization and it pays attention to the "distinctive personality" of urbanization[5]; some people hold that the "new" of new urbanization is to improve the quality of urbanization construction, pay attention to regional balance and narrow the gap between cities and towns[6]; others believe that the key to new urbanization is "people-oriented", focusing on improving the level of human living environment[7]. Scholars hold different views, and there is no consensus on how to define "new urbanization". This paper see the new urbanization from the perspective of green development. Green development should achieve high added value, sustainability, and system optimization while achieving low pollution, green environment, and ecological protection. It should be the comprehensive development of green economy, green environment, green life and green foundation, so as to realize the green organic unity of urban economy, urban life quality and urban natural environment.

2. Index system construction
Taking the current situation of new urbanization construction and connotation of the green perspective in Anhui Province as the guiding ideology, this study added research indicators suitable for the development of new urbanization in Anhui Province on the basis of improving the original mathematical model and evaluation system; the index system focused on the green perspective, including four primary indicators and fourteen secondary indicators. Specific indicators are shown in Table 1.

| Primary indicators     | Secondary indicators(units)                        | Contribution | Indicators code |
|------------------------|---------------------------------------------------|--------------|-----------------|
| Green economy          | Increase in energy consumption per unit of production(%) | Negative     | X1              |
|                        | Cost per unit of wastewater discharge(RMB/ton)     | Negative     | X2              |
|                        | Cost per unit of emissions(RMB/m³)                | Negative     | X3              |
|                        | Consumption per unit of solid waste(RMB/ton)       | Negative     | X4              |
|                        | Good air quality rate(%)                          | Positive     | X5              |
| Green environment      | Harmless disposal capacity of garbage(10000 tons) | Positive     | X6              |
|                        | Number of civil vehicle ownership                 | Negative     | X7              |
|                        | Urban sewage discharge(10000 m³)                  | Negative     | X8              |
|                        | Cleaning area(100 million m²)                     | Positive     | X9              |
|                        | Green coverage area(m²)                           | Positive     | X10             |
| Green living           | Investment in environmental facilities(RMB 10 thousand) | Positive | X11             |
|                        | Number of public toilets in cities and towns       | Positive     | X12             |
|                        | Years of education per capita                     | Positive     | X13             |
|                        | Fixed investment in health(RMB 10 thousand)       | Positive     | X14             |

3. Research Method
Objective weighting methods mainly include entropy method, principal component method and factor analysis method[8]. Considering that the data needed for the study needs to be extracted from the data group of variables, the span is large, so factor analysis method is adopted this time to obtain the weight ratio of the index model. On the basis of the study on the correlation coefficient matrix of the variables of the new urbanization index model in Anhui Province from the green perspective, this paper deduces a few model variables which are difficult to observe to control all variables, and then describes the original correlation between variables through them. The specific steps are as follows:

1) Standardize the processing of research data and eliminate differences in data indicators
2) Assume that the original data can be matrixed, the matrix is:
where \( n \) is number of samples, \( p \) is number of variables.

First, calculate the average value of the indicators from 2009 to 2018:

\[
\bar{X}_{ij} = \frac{\sum_{t=2009}^{t=2018} X_{ijt}}{10}
\]

where \( i \) is \( x \) indicators, \( j \) is \( x \) cities, \( t \) is data from 2008 to 2019 of indicators; Considering that many index systems have different units and the calculation without processing will lead to great deviation, therefore, the dimensionless standardization of the range is carried out, the formula is as follows:

\[
X'_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} 	ext{ or } X'_i = \frac{x_{\max} - x_i}{x_{\max} - x_{\min}}
\]

where \( X'_i \) is the value of the i-th indicators after dimensionless treatment, \( x_i \) is the actual value of the i-th indicator, \( x_{\max} \) is the maximum value of the i-th indicator, \( x_{\min} \) is the minimum value of the i-th indicator.

(2) Estimating factor load matrix

The load matrix of factors mainly includes Q type and R type. Most studies choose R type as the research method. Assuming that there are \( m \) variables \( a_m \), and the average value of each variable is 0, and its standard deviation is 1, now all the original variables are represented by the linear combination of \( P \) (\( P < m \)) factors \( Y_P \), and the basic model is as follows[34]:

\[
\begin{align*}
Z_1 &= a_{11}Y_1 + a_{12}Y_2 + \ldots + a_{1p}Y_p + C_1U_1 \\
Z_2 &= a_{21}Y_1 + a_{22}Y_2 + \ldots + a_{2p}Y_p + C_2U_2 \\
Z_m &= a_{m1}Y_1 + a_{m2}Y_2 + \ldots + a_{mp}Y_p + c_mU_m
\end{align*}
\]

where \( Z_m \) is the original variable; \( Y_p \) is common factor, the matrix expressed is as follows:

\[
\begin{pmatrix}
Z \\
\end{pmatrix}
= \begin{pmatrix}
A & Y & C \\
\end{pmatrix}
\begin{pmatrix}
\begin{pmatrix}
\begin{pmatrix}
(m \times l) \\
\end{pmatrix}
\end{pmatrix}
\end{pmatrix}
\begin{pmatrix}
\begin{pmatrix}
\begin{pmatrix}
(m \times n) \\
\end{pmatrix}
\end{pmatrix}
\end{pmatrix}
\begin{pmatrix}
\begin{pmatrix}
\begin{pmatrix}
(m \times l) \\
\end{pmatrix}
\end{pmatrix}
\end{pmatrix}
\]

(3) Factor rotation

After the above factor model is established, the common factors of the model should be found and grouped. Only by knowing the meaning of all common factors can we analyse the actual problems of new urbanization in Anhui Province from the green perspective. When the load matrix \( A \) of the factor is difficult to interpret the main factor analysis, an orthogonal matrix can be multiplied by \( A \) to the right. In other words, the orthogonal transformation is applied to \( A \), and its corresponding coordinates will rotate, which makes it easier to explain and analyse the change of factors.

(4) Estimate factor score

The linear combination of the original variables can be expressed by common factors, and then the factor score model is obtained, and then the value of each common factor is measured by the factor score model.

\[
Z = x_1F_1 + x_2F_2 + \ldots + x_mF_m
\]
where $Z$ is comprehensive score; $X_m$ is secondary indicators; $F_m$ is main factor score weight.

4. The Empirical Analysis

4.1. Main analysis process

The data sources of this study roughly include the following aspects: first, the urban basic data on 16 cities in Anhui Province from 2009 to 2018, and then the development data of new urbanization. The data mainly come from the statistical yearbook of 2009 to 2018, the environmental Bulletin of each city, the work report of Anhui provincial government and municipal government in recent ten years. From 2009 to 2018, the average value of the indicators of each city in Anhui Province are calculated, and the specific data are shown in Table 2.

According to the gravel diagram (Figure 1), it is appropriate to extract three common factors.

According to the rotated component matrix (Table 3), the first of the common factors has a large load on $X_8$, $X_6$, $X_9$, $X_{14}$, $X_{11}$, $X_{10}$, $X_{13}$, $X_7$, $X_2$. These nine indicators reflect green living and green environment, and can be named as green living environment factor. The load of the second factor is larger on $X_3$, $X_4$, $X_1$ and $X_5$. These indicators reflect the changes of green economic factor and can be named as green economic factor. The third factor has a larger load on $X_{12}$. This indicator is a green foundation factor and can be named as green foundation factor.

| Factors | Component 1 | Component 2 | Component 3 |
|---------|-------------|-------------|-------------|
| Urban sewage discharge (X8) | .969 | -.126 | .152 |
| Harmless disposal capacity of garbage (X6) | .955 | -.102 | .231 |
| Cleaning area (X9) | .945 | -.149 | .220 |
| Fixed investment in health (X14) | .930 | -.052 | .328 |
| Investment in environmental facilities (X11) | .921 | .051 | .060 |
| Green coverage area (X10) | .813 | .491 | -.186 |
| Years of education per capita (X13) | .797 | -.272 | -.340 |
| Number of civil vehicle ownership (X7) | .754 | .000 | .536 |
| Cost per unit of wastewater discharge (X2) | .632 | .486 | .456 |
| Cost per unit of emissions (X3) | .120 | .950 | -.101 |
| Consumption per unit of solid waste (X4) | .150 | .912 | -.193 |
| Increase in energy consumption per unit of production (X1) | -.291 | .907 | .102 |
| Good air quality rate (X5) | -.458 | .742 | -.190 |
| Number of public toilets in cities and towns (X12) | .160 | -.274 | .713 |

In summary, combined with principal component analysis, Table 3 can be obtained.

| Factors | Component 1 | Component 2 | Component 3 |
|---------|-------------|-------------|-------------|
| Increase in energy consumption per unit of production(X1) | -.069 | .254 | .196 |
| Cost per unit of wastewater discharge(X2) | .036 | .163 | .317 |
| Cost per unit of emissions(X3) | .033 | .250 | -.034 |
| Consumption per unit of solid waste(X4) | .052 | .233 | -.117 |
| Good air quality rate(X5) | -.051 | .189 | -.033 |
| Harmless disposal capacity of garbage(X6) | .127 | -.014 | .037 |
| Number of civil vehicle ownership(X7) | .046 | .036 | .330 |
| Urban sewage discharge (X8) | .142 | -.026 | -.032 |
| Cleaning area (X9) | .127 | -.028 | .027 |
| Green coverage area (X10) | .165 | .117 | -.244 |
| Investment in environmental facilities (X11) | .147 | .015 | -.088 |
| Number of public toilets in cities and towns (X12) | -.082 | -.023 | .549 |
Years of education per capita (X13) & .189 & -.101 & -.425 \\ Fixed investment in health (X14) & .108 & .007 & .126 \\

| Cities | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 |
|--------|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|
| Hefei  | -5.17 | 1.03 | 2.68 | 6.33 | 76.73 | 110.99 | 1076408.8 | 40242.6 | 0.56 | 16953.4 | 4326930.13 | 219.0 | 10.00 | 454100.84 |
| Huaibei | -5.15 | 0.30 | 0.60 | 0.65 | 80.75 | 21.52 | 208894.1 | 4636.5 | 0.09 | 4161.8 | 313967.42 | 52.7 | 9.10 | 35346.83 |
| Bozhou | -4.46 | 0.39 | 2.12 | 3.74 | 83.43 | 15.60 | 406743.4 | 4013.5 | 0.11 | 2359.1 | 509727.56 | 270.0 | 7.91 | 82907.32 |
| Suzhou | -4.91 | 0.32 | 1.34 | 2.43 | 81.68 | 18.95 | 349645.6 | 4444.0 | 0.13 | 3371.1 | 371796.73 | 141.8 | 8.29 | 100385.58 |
| Bengbu | -5.10 | 0.43 | 1.43 | 6.17 | 81.39 | 32.40 | 284520.3 | 13261.1 | 0.16 | 5554.5 | 800412.35 | 341.0 | 9.14 | 129318.17 |
| Fuyang | -4.42 | 0.45 | 1.58 | 2.49 | 83.24 | 25.62 | 605169.9 | 5972.5 | 0.12 | 4670.4 | 641250.62 | 163.1 | 8.13 | 105675.33 |
| Huainan | -4.96 | 0.13 | 0.31 | 0.33 | 81.14 | 31.43 | 244207.5 | 7965.5 | 0.20 | 4817.8 | 789410.35 | 287.4 | 9.10 | 75173.80 |
| Chaohou | -4.95 | 0.30 | 1.18 | 5.64 | 82.75 | 13.72 | 339108.8 | 5266.2 | 0.13 | 4326.6 | 1259202.33 | 153.4 | 8.65 | 95907.60 |
| Lu'an | -4.16 | 0.70 | 2.03 | 1.79 | 89.06 | 18.68 | 423701.9 | 4049.9 | 0.08 | 3231.4 | 1191277.86 | 261.5 | 8.27 | 94505.00 |
| Ma'anshan | -5.42 | 0.17 | 0.22 | 0.57 | 82.04 | 20.44 | 176900.0 | 11561.2 | 0.11 | 5761.2 | 1652705.95 | 107.4 | 8.98 | 71584.88 |
| Wuhu | -5.46 | 0.59 | 0.85 | 6.24 | 85.67 | 43.26 | 348258.9 | 13551.9 | 0.23 | 6393.4 | 1341353.58 | 255.3 | 9.16 | 167057.17 |
| Xuancheng | -5.04 | 0.32 | 0.75 | 2.95 | 89.67 | 12.88 | 267590.2 | 2131.2 | 0.07 | 3769.1 | 1216454.52 | 86.6 | 8.28 | 81032.01 |
| Tongling | -4.97 | 0.18 | 0.34 | 0.52 | 87.17 | 14.79 | 105703.0 | 4835.7 | 0.11 | 5027.5 | 838270.67 | 144.0 | 9.23 | 47528.34 |
| Chizhou | -4.33 | 0.50 | 0.45 | 2.67 | 91.31 | 12.32 | 124772.0 | 2320.9 | 0.07 | 1750.7 | 475179.42 | 133.8 | 8.29 | 26133.43 |
| Anqing | -4.82 | 0.36 | 1.15 | 6.44 | 86.01 | 21.20 | 394325.3 | 6527.7 | 0.12 | 9844.2 | 1648523.97 | 179.2 | 8.54 | 89141.21 |
| Huangshan | -2.88 | 0.62 | 10.60 | 27.95 | 98.08 | 11.74 | 152205.2 | 2903.3 | 0.06 | 13821.9 | 1001212.67 | 53.8 | 8.54 | 41305.92 |

Figure 1. The Gravel diagram

4.2. Analysis result

Through the comprehensive analysis, the scores of comprehensive factors of new urbanization in Anhui Province can be calculated, as shown in Table 5.

Table 5. The scores of comprehensive factors of new urbanization in Anhui Province

| Cities | Green living environment factor (Y1) | Green economic factor (Y2) | Green foundation factor (Y3) | Comprehensive score (Z) | Ranking |
|--------|----------------------------------|--------------------------|------------------------------|-------------------------|---------|

Combined with the above research and after repeated calculation, the optimal range is four. Therefore, the new urbanization level of each city in Anhui Province from 2009 to 2018 can be divided into four levels, as shown in Figure 2.

![Figure 2. The chart of new urbanization level in Anhui Province](image)

As can be seen from Table 5 and Figure 2 that the green living environment factor (Y1) of Hefei and Wuhu and the green Economy factor (Y2) of Huangshan are significantly higher than those of other cities. These three cities are in the highest level of new urbanization level among all cities in Anhui Province from the green perspective, focusing on green living environment and green infrastructure construction. Anqing, Bengbu, Lu'an and Fuyang are in the second level, they have a good green foundation, and their future development should focus on the improvement of green living and green environment. Chuzhou, Bozhou, Ma'anshan, Huainan, Suzhou and Xuancheng are in the third level, their green development is expanding rapidly, and the four aspects of urbanization should be guided by the concept of overall planning for green development. Tongling, Chizhou and Huaibei are in the fourth level, and all aspects of green development are at the initial stage.

From the green perspective, the level of new urbanization in Anhui Province shows regional differences from 2009 to 2018. Among them, the central region has the highest level of new
urbanization from the green perspective, followed by the west region, the east region is at the third level, and the southwest region and northeast region are at the fourth level.

5. Conclusion
Taking new urbanization as the research object, this paper constructs the new urbanization index system from the green perspective, a total of 14 indicators from the four levels of green economy, green environment, green living, and green foundation are studied for the new urbanization level of 16 cities in Anhui Province from the green perspective, and the data model of new urbanization in Anhui Province from the green perspective is established. Through analysis, the development level of new urbanization in Anhui Province can be divided into four levels from the green perspective, with the highest level in the central region, the second level in the west, the third level in the east, and the fourth level in the southwest and northeast. This research provides a scientific basis for the follow-up analysis and provides ideas for the healthy development of new urbanization.

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