The Spatio-Temporal Characteristics of the Coordinated Development of Urbanization and Resources Environmental Carrying Capacity in Lanzhou-Xining Urban Agglomeration

Wei-ping ZHANG and Pei-ji SHI

School of Geography and Environmental Sciences, Northwest Normal University, Lanzhou 730070, P.R. China

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Abstract. The coordination of urbanization and resources and environment is one of the key issues to promote regional social and economic development. This paper took Lanzhou-Xining urban agglomeration as the study area, constructed the evaluation index of urbanization and resource environmental carrying capacity first, and then used entropy method and the coordination degree model to measure the coordination of urbanization and resource environmental carrying capacity from 2005 to 2017. Results indicate that the overall index of urbanization and resource environmental carrying capacity of Lanzhou-Xining urban agglomeration shows an upward trend, and there are obvious spatial differences, especially between Lanzhou and Xining and the surrounding counties. The coordination degree of urbanization and resource environmental carrying capacity is between [0.5, 0.6), most of the counties are in a state of reluctance coordination, and the spatial distribution law of the degree is high in the east and low in the west. And the regional differences are gradually shrinking. There is a significant positive correlation between urbanization and capacity. The coordination status of Lanzhou and Xining provincial cities is relatively good, and the urbanization level is lower.

Introduction

Urbanization is an inevitable trend of regional development. It is a complex process of urban spatial expansion, population transformation and economic and social development. Also, it is a necessary process for a country to achieve industrialization and modernization [1]. Since the reform and opening up, while the economy has grown rapidly, China has experienced unprecedented urbanization in world history [2]. In 2005-2017, China's urbanization rate rose from 42.99% to 58.52%, and it has fully entered the stage of rapid urbanization development [3]. This traditional development model of promoting industrialization and urbanization with long-term dependence on resource consumption has brought many problems while promoting economic development. In some areas, urban-rural regional development imbalances, urban scale structure imbalance, regional development and construction intensity have emerged increasingly increasing, there source utilization efficiency levels drop, environmental pollution and other problems are intensifying, and the ecological environment system is overwhelmed, which has affected the development of human society and economy to some extent [4]. The 19th National Congress of the Communist Party of China (CPC) made clear instructions on the development of urban agglomerations. It is necessary to fully integrate the concept and principles of ecological civilization into the whole process of urbanization, and form an urban pattern of coordinated development of large, medium, and small cities and small towns, and pursue a new urbanization road that is intensive, intelligent, green and low carbon. Therefore, coordinating the harmonious relationship between urbanization and resource environmental carrying capacity is the only way to promote the development of new urbanization [5].

At present, the academic research on urbanization and resources environmental carrying capacity
has shifted from the relationship between urbanization and single environmental factors to the study of the relationship between comprehensive environmental elements and urbanization, and from static mechanism analysis to dynamic characteristic analysis of time series. According to the current research results found that most of the research contents are focused on the spatial evolution of the coordination degree of urbanization development [6,7], the spatial and temporal evolution characteristics of resources environmental carrying capacity[8], the relationship between urbanization and ecological environment [9,10], the new phenomenon of growth and contraction in the development of rapid urbanization areas [11], the urbanization evolution based on water resources constraints [12], the relationship between economic growth and resources and environment [13], the resource and environment effects of urban spatial expansion [14] and the binding effect of resources and environment on urban development [15], etc, while there is little analysis and research on the spatial and temporal characteristics of the coordinated relationship between urbanization and resources environmental carrying capacity. From the research method, most of them use entropy weight TOPSIS model [16], the coupling degree function [17], the matrix method, the data envelopment analysis method, the elastic index method [18], the analytic hierarchy process, the responsive model [19] and the system dynamics model [20] to measure, evaluate and predict the coupling degree and coordination degree of urbanization and resource environment, and identify the influencing factors to achieve quantitative assessment of the relationship between the two. From the research area, the national [21], the provincial [22], the prefecture-level cities and urban interiors [23] are the main research areas [24], and they are mostly distributed in areas with high economic development level. However, there is less research on the coupling and coordination of the relationship between urbanization and resource environmental carrying capacity in the northwest region China of the pace of urbanization is accelerating.

The Lanzhou-Xining urban agglomeration is a pivotal urban cluster in the “Silk Road Economic Belt”, with the Hehuang region, where population and industry are concentrated, as its basic bearing area. It is an important radiation center and growth pole for economic development in Gansu, Qinghai and Northwest China, and is also a relatively fragile area in the northwestern ecological environment. The study of the interaction and coordination between urbanization development and resource environmental carrying capacity is typical. In view of this, this paper takes Lanzhou-Xining urban agglomeration as an example, based on the actual development of 39 counties and districts, with 2005, 2010, 2015 and 2017 for the time section, comprehensively considering the factors affecting the development of urbanization and the carrying capacity of resources and environment. Based on the analysis of the temporal and spatial relationship between urbanization and resource and environment system, the coordination degree model is used to explore the characteristics of the coordination relationship between the two. So that the new urbanization development road based on the carrying capacity of resources and environment is revealed, which provides a reference for the realization of the coordinated development of new urbanization and resources environmental carrying capacity in Lanzhou-Xining urban agglomeration.

Materials and Methods

Study Area

Lanzhou-Xining urban agglomeration is located in the inland area of western China. It is the ecological security barrier supporting area in the upper reaches of the Yellow River and the northeastern part of the Qinghai-Tibet Plateau. It is also the intersection of the Qinghai-Tibet Plateau, Loess Plateau and Inner Mongolia Plateau. According to the document "Development Planning of Lanzhou-Xining Urban agglomeration" issued by the National Development and Reform Commission shows that the research scope of the urban agglomeration is Lanzhou City, Baiyin District, Pingchuan District, Jingtai County, Jingyuan County, Gansu Province. Dingxi Anding District, Longxi County, Weiyuan County, Jingyuan County, Lintao County, Linxia Hui Autonomous Prefecture Linxia City, Dongxiang County, Yongjing County, Jishishan County, Xining City,
Haidong City, Haiyan County, Haibei Tibetan Autonomous Prefecture, Hainan Tibetan Autonomous Prefecture Zhizhou Gonghe County, Guide County, Guinan County, Tongren County, Jianza County, Huangnan Tibetan Autonomous Prefecture, a total of 39 counties (districts, cities), as shown in Figure 1. The terrain is high in the northwest and low in the southeast, and is dominated by mountainous and river valleys. It is an important urban cluster in the Silk Road Economic Belt and an important radiation center and growth pole in Gansu and Qinghai. By the end of 2017, the total population of Lanzhou-Xining urban agglomeration was 11.8413 million, of which the number of Gansu provinces was 7,498,200, the Qinghai area was 4,243,100. The resident population was 11.886 million, and the resident population urban rate reached 60.02%. Its GDP was 500.574 billion yuan, the growth rate reached 6.52% in that year. The per capita GDP was 39,853.21 yuan, and the level of urbanization has increased rapidly.

Figure 1. The study region.

**Data Sources**

The data in this paper mainly came from the 2005-2017 China Urban Statistical Yearbook, Gansu Statistical Yearbook, Qinghai Statistical Yearbook, Gansu Province (County City Construction Statistics Annual Report), and Qinghai Province City (County City) Construction Statistics. The annual report, the Gansu Water Resources Bulletin, the Qinghai Water Resources Bulletin, the statistical bulletin for national economic and social development in the relevant counties of 39 counties in the Lanzhou-Xining urban agglomeration, and the number of surveys by the municipal and state environmental protection bureaus and the Water Affairs Bureau are partially missing. The data was supplemented by local government work reports and data for adjacent years.

**Construction of Indicator System**

Through the combing and comparison of the literature, this paper comprehensively considered the actual status of the two systems of urbanization and resources environmental carrying capacity in Lanzhou-Xining urban agglomeration area. And combined with the availability of data and the comprehensive, typical and scientific principles of index system, the index system was constructed from two major directions: urbanization system and resource environmental carrying capacity system [20, 25]. Urbanization is mainly the transformation of rural population, production and lifestyle and land use types into urbanization mode respectively. So the secondary index was selected from the four criteria of population, economy, society and space urbanization, and 16 third-level indicators were selected according to the status of secondary indicators. As the link
between the social economic system and the resource environment system, the resource environmental carrying capacity is the ability of the resource and environment system for human society and economy in a certain period and a certain geographical area. That is, it reflects the carrying capacity of the natural foundation to the maximum economic scale and population size under the conditions of the upper limit constraint. Therefore, based on the needs of human activities and the optimization of ecological protection modes and the local conditions of the Lanzhou-Xining urban agglomeration, this paper constructed two-level indicators from the three aspects of resource and environmental pressure, resource and environmental load and resource and environmental performance. Fourteen three-level indicators were selected (Table 1).

| System                        | Subsystem                      | Evaluation Indicator                                                                 | Indicator properties | Indicator weight |
|-------------------------------|--------------------------------|--------------------------------------------------------------------------------------|----------------------|------------------|
| Economic urbanization         | Population urbanization         | Urbanization rate of permanent residents                                            | positive             | 0.0480           |
|                               |                                | Population density                                                                  | positive             | 0.1664           |
|                               |                                | The proportion of employees in the secondary and tertiary industries                 | positive             | 0.0429           |
|                               |                                | Per capita GDP                                                                      | positive             | 0.0512           |
|                               |                                | Per capita local fiscal revenue                                                     | positive             | 0.0659           |
|                               |                                | Per capita social fixed assets investment                                           | positive             | 0.0596           |
|                               | Economic urbanization          | Gross industrial output value above designated size                                 | positive             | 0.1145           |
|                               |                                | The added value of the secondary and tertiary industries accounts for the proportion of GDP | positive             | 0.0405           |
|                               |                                | Per capita disposable income of urban residents                                     | positive             | 0.0209           |
|                               | Social urbanization            | Total retail sales of consumer goods per capita                                      | positive             | 0.0962           |
|                               |                                | 10,000 people have the number of teachers                                           | positive             | 0.0234           |
|                               |                                | 10,000 people have mobile phone users                                              | positive             | 0.0388           |
|                               |                                | Number of beds in hospitals and health centers per 1,000 population                | positive             | 0.0461           |
|                               | Spatial urbanization           | Public library collections per 100 people                                           | positive             | 0.1041           |
|                               |                                | Per capita built-up area                                                            | positive             | 0.0460           |
|                               |                                | Per capita urban road area                                                          | positive             | 0.0354           |
|                               |                                | Per capita industrial wastewater discharge                                         | negative             | 0.0173           |
|                               | Resource environment pressure  | Per capita industrial SO\textsubscript{2} emissions                                  | negative             | 0.0202           |
|                               |                                | Per capita industrial waste gas emissions                                           | negative             | 0.0212           |
|                               |                                | Per capita industrial solid waste production                                       | negative             | 0.0135           |
|                               | Resource environment load      | Per capita cultivated area                                                          | positive             | 0.1386           |
|                               |                                | Per capita water resources                                                          | positive             | 0.0602           |
|                               |                                | Forest cover rate                                                                  | positive             | 0.1355           |
|                               |                                | Green area coverage rate in built-up area                                           | positive             | 0.0609           |
|                               |                                | Per capita public green area                                                        | positive             | 0.0818           |
|                               |                                | Urban domestic sewage treatment rate                                                | positive             | 0.0612           |
|                               |                                | Harmless treatment rate of domestic garbage                                         | positive             | 0.0261           |
|                               | Resource environment performance| Comprehensive utilization rate of industrial solid waste                          | positive             | 0.0368           |
|                               |                                | Environmental pollution control investment accounts for the proportion of GDP        | positive             | 0.2611           |
|                               |                                | The proportion of days with AQI index ≤100                                          | positive             | 0.0655           |

**Entropy Method Weighting**

Since there are differences in the data unit dimensions of the urbanization system and the resource environment system indicators, and each indicator has both positive and negative effects, which cannot be directly compared. Therefore, it is necessary to standardize the pre-processing of each indicator data, so that the processed data index values are normalized to [0, 1] [26]. The standardized processing formula is:

\[
x_{ij} = \left( x_{ij} - x_{\text{min}} \right) / \left( x_{\text{max}} - x_{\text{min}} \right)
\]  

(1)
Where, $x_{ij}$ is the measured data values, $x_{max}$ and $x_{min}$ respectively are the maximum and minimum values in the measured data, $x_{ij}'$ represents the normalized value.

Because the degree of dispersion of different indicators is different, the impact of indicators on comprehensive evaluation is also different. Therefore, using the more objective entropy method to determine the weight of different evaluation indicators has greater rationality[27]. The main steps is as follows:

The first step is to calculate the entropy value corresponding to each indicator:

$$H_j = -k \sum_{i=1}^{m} (Y_{ij} \times \ln Y_{ij})$$  \hspace{1cm} (2)

In the form, $H_j$ is the entropy value, $m$ is the number of research samples, $k=1/(ln m)$, Among $Y_{ij}$ is the indicator weight, stipulate $Y_{ij} = x_{ij}/\sum_{i=1}^{m} x_{ij}$.

The second step is to calculate the weights corresponding to each indicator:

$$W_j = (1 - H_j) / \sum_{j=1}^{n} (1 - H_j)$$  \hspace{1cm} (3)

In the form, $W_j$ is the weight of the evaluation indicator, $n$ is the number of indicators.

The final step is to use the weighted summation formula to find the composite index:

$$F_i = \sum_{j=1}^{n} (W_j \times x_{ij})$$  \hspace{1cm} (4)

$F_i$ is the comprehensive index of urbanization and resource environmental carrying capacity. The weights of the evaluation indicators for urbanization and resources environmental carrying capacity from 2005 to 2017 are shown in Table 1.

**Coupling Coordination Model**

Drawing on the concept of system coupling derived from physics, geoscientists introduced it as a measure to reveal the degree of interaction and synergy between two or more systems. The two systems of urbanization and resource environmental carrying capacity are closely related to each other, and the two influence each other. Therefore, the coupling theory can be used to study the interaction between the two [11].The calculation model is as follows:

$$C = 2\{f(x) \times g(y) / [f(x) + g(y)]\}^{1/2}$$  \hspace{1cm} (5)

Since the degree of coupling cannot represent the comprehensive coordination level of the two, especially in some cases, it is difficult to truly reflect the overall “efficacy” and “synergy” effects, which may result in two systems with low development level and high coupling degree. In order to solve this problem, the coupling coordination degree model is further introduced to analyze the degree of interaction and coordination between urbanization and resource environmental carrying capacity in urban agglomeration.

$$D = \sqrt{C \times T}$$  \hspace{1cm} (6)

$$T = \alpha f(x) + \beta g(y)$$  \hspace{1cm} (7)

In the formula, $C$ indicates that the coupling degree, $f(x)$ is the comprehensive evaluation index of urbanization, $g(y)$ is the comprehensive evaluation index of resource environmental carrying capacity. $T$ indicates the comprehensive development index of the two systems. $\alpha$ and $\beta$ are undetermined coefficients, respectively indicating the importance of urbanization and resources environmental carrying capacity, because the two need to coordinate and work together, almost equally important, $\alpha=\beta=0.5$ in this paper. $D$ represents the coupling coordination degree, and the value is between 0 and 1. The bigger the $D$ value, the higher the coordination. Based on the relevant research and the actual size of the research area, the coordinated development degree of urbanization and resource environmental carrying capacity is divided into seven types (Table 2).
Table 2. Coupling coordination degree type and its division standard.

| Coordination Degree | 0<D<0.3 | 0.3≤D<0.4 | 0.4≤D<0.5 | 0.5≤D<0.6 | 0.6≤D<0.7 | 0.7≤D<0.8 | 0.8≤D≤1 |
|---------------------|---------|-----------|-----------|-----------|-----------|-----------|---------|
| Coordination Level   | Serious disorder | Mild disorder | Close coordination | Reluctant coordination | Moderate coordination | Good coordination | Superior coordination |

Result Analysis

Temporal and Spatial Characteristics of Urbanization

From 2005 to 2017, 39 counties (districts) in Lanzhou-Xining urban agglomeration were used as horizontal comparison units found that the urbanization level showed an overall growth trend. The comprehensive index increased from 0.207 in 2005 to 0.254 in 2017, and the difference between the maximum value and the minimum value was mainly between 0.5 and 0.6. From the change of the average contribution of the sub-system index of urbanization, the population urbanization index increased year by year in 2005-2017, and the urban population increased rapidly. By 2017, the urbanization rate reached 60%, which was higher than the national average of 58.5%. The social urbanization and spatial urbanization index also showed an upward trend in volatility, while the economic urbanization index declined (Table 3), which indicates that function of central city has improved in recent years with the improvement of living standards. Also, the basic public service capacity of urban and rural areas has been gradually improved, and the development of urban and rural integration is better. However, the Lanzhou-Xining urban agglomeration area located in the northwest inland has a weak economic foundation, and the economic development level and urban development level of urban agglomerations are quite different. In 2005, the number of counties in the Lanzhou-Xining urban agglomeration area that was lower than the regional urbanization average reached 24, accounting for 61.55% of the total number of research units. In 2017, there were 22 counties in the lower than the regional average level of urbanization, accounting for the total 56.44% of the study area, the urbanization development level of the Lanzhou-Xining urban agglomeration area is mainly at the low level. The standard deviations of urbanization levels in 2005, 2010, 2015 and 2017 were 0.139, 0.133, 0.139, and 0.149, respectively. The number of counties below the average level of urbanization decreased to a certain extent, while the overall gap of urbanization levels in counties is expanding.

In order to further explain the spatial pattern distribution of the urbanization level of the Lanzhou-Xining urban agglomeration, based on the ArcGIS platform, the natural breakpoints were used to divide the urbanization level of the Lanzhou-Xining urban agglomeration into five major types: high, higher, medium, and lower and low level zones (Figure 2). Figure 2 showed that, as a whole, the urbanization rate of the Lanzhou-Xining urban agglomeration area was high, and the higher level areas were mainly distributed in Lanzhou City, Xining City, Baiyin City, Anding District, Haidong City and Linxia City. Most of the counties in Jingyuan, Huzhu, Minhe County and the southern part of the Lanzhou-Xining urban agglomeration had low urbanization rates, and the imbalance in the development of counties and districts in the region was prominent. The urbanization high-level areas were relatively concentrated in spatial distribution, mainly in Lanzhou City and Xining City; the urbanization was higher and the medium-level areas were mainly distributed in the surrounding areas of urbanization high-level areas. The lower level areas of urbanization were mainly distributed in Minhe County, Dingxi City, Yongjing County and Qinghai, Minhe, Huzhu, Xunhua and Jianzha counties. The southern part of Lanzhou-Xining urban agglomeration had the lowest level of urbanization, such as Dongxiang, Jishishan, Hualong and Tongren County. From 2005 to 2017, the dynamic level of the urbanization level of Lanzhou-Xining urban agglomeration showed that there were obvious spatial differences in the fluctuations of urbanization levels in various counties. The regions with larger growth rates mainly concentrated in Yongdeng, Jingyuan and Dongxiang counties in Gansu and Gonghe County of Qinghai, and some
counties and districts maintained their original level and even experienced negative growth, which is closely related to the economic foundation of the city itself, such as weak industrial base, low level of information technology, relative lack of foreign capital, and uncoordinated urban development strategy. According to comprehensive analysis, the economic development level and urban development level of the Lanzhou-Xining urban agglomeration are quite different, the polarization is obvious, and the regional development is unbalanced. The lack of long-term space control measures makes the two provincial capital cities of Lanzhou and Xining unique, the urban level is too low, and the polarization of the polarized area is limited. The imbalance of regional development limits the function of the urban agglomeration and the integration and balanced development of regional economies.

Table 3. The dynamics comparison results of urbanization subsystems in 2005-2017.

| Subsystems time | Average of population urbanization index | Average of economic urbanization index | Average of social urbanization index | Average of spatial urbanization index |
|-----------------|----------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| 2005            | 0.236                                  | 0.347                                | 0.341                               | 0.076                               |
| 2010            | 0.233                                  | 0.416                                | 0.292                               | 0.059                               |
| 2015            | 0.280                                  | 0.307                                | 0.328                               | 0.086                               |
| 2017            | 0.280                                  | 0.258                                | 0.357                               | 0.105                               |

Figure 2. Spatial pattern evolution of urbanization in Lanzhou-Xining urban agglomeration.

**Temporal and Spatial Characteristics of Resource Environmental Carrying Capacity**

In 2005, 2010, 2015 and 2017, the standard deviations of resource environmental carrying capacity levels in the Lanzhou-Xining urban agglomeration were 0.071, 0.095, 0.103, and 0.108 respectively. It can be seen that the gap in the development level of resource environmental carrying capacity among counties and districts had increased. However, compared with the standard deviation of urbanization level in the Lanzhou-Xining urban agglomeration, the gap between the resource environmental carrying capacity of the county was significantly smaller than the urbanization level. In 2005, the gap between the highest value and the lowest value of comprehensive index of resource environmental carrying capacity was 0.36, and by 2017 the gap between the highest and lowest value was reduced to 0.34, while the coefficient of variation of resource environmental carrying capacity increased from 0.208 in 2005 to 0.259 in 2017, which indicate that the carrying capacity of resources and environment in Lanzhou-Xining urban agglomeration fluctuates greatly from year to year, and the regional differences continued to increase. From the dynamic change of resource environmental carrying capacity (Table 4), each subsystem had different degrees of change, and the resource environment pressure subsystem and performance subsystem index showed a "U" type change trend, while the resource environment load sub-system showed a steady trend after rising.

Based on the GIS platform, the breakpoint method was used to classify the development level of resource environmental carrying capacity into five types: low, lower, medium, higher and high
Figure 3 showed that resource environmental carrying capacity comprehensive index of the Lanzhou-Xining urban agglomeration had a large spatial difference, which was generally characterized by east high and west low and middle high and periphery low. The resource environmental carrying capacity high-level and the higher-level areas were mainly the municipal districts represented by Lanzhou City and Xining City. The low-level areas were mainly concentrated in most counties and districts in Qinghai, and degree of dispersion of the comprehensive index of resource environmental carrying capacity in the county was low and the spatial agglomeration characteristics were obvious. The dynamic degree of resource environmental carrying capacity of 39 research units in 2005-2017 showed spatial heterogeneity. The growth rate of the eastern counties of Lanzhou-Xining urban agglomeration was larger than that of western counties. Honggu, Baiyin, Pingchuan, and Lanxian and Chengxi Districts had the highest growth, and some counties had negative growth, such as Ping’an District, Haishu, Mutual, Guide, Tongren and Jishishan County. In summary, some counties and districts that were in a low-level resource environment are closely related to their fragile natural environment, weak economic foundation, limited technological level, and lack of attention to resources environmental issues. While the carrying capacity of a few counties has been significantly improved, especially is in the representative areas with high economic development level and obvious traffic (Lanzhou, Baiyin and Xining City). On the one hand, these counties are located in the valley basin area, and the water and soil resources are well combined. On the other hand, actively implement environmental protection standards, increase environmental protection efforts, and continuously improve resource utilization, so that the resources and environment are further optimized and upgraded.

Table 4. The dynamics comparison results of resource environmental carrying capacity subsystem in 2005-2017.

| Subsystems time | Average value of resource and environmental stress index | Average value of resource environmental load index | Average of resource and environmental performance index |
|-----------------|--------------------------------------------------------|---------------------------------------------------|------------------------------------------------------|
| 2005            | 0.063                                                  | 0.356                                             | 0.581                                                |
| 2010            | 0.053                                                  | 0.376                                             | 0.571                                                |
| 2015            | 0.063                                                  | 0.501                                             | 0.436                                                |
| 2017            | 0.081                                                  | 0.476                                             | 0.443                                                |

Figure 3. Spatial pattern evolution of resource environmental carrying capacity.

Coordination Relationship between Urbanization Resources Environmental Carrying Capacity

As a center of regional development, towns have the effects of factor agglomeration and scale. The rapid development of urbanization will affect the resources and environment to some extent. As the material basis and carrier space of urbanization development, the resource environmental carrying capacity is not only driven by the externalization of the urbanization process, but also by its own
internal factors. Therefore, the coordinated analysis of urbanization and resource environmental carrying capacity should focus on the local response of resource environmental carrying capacity in the process of urbanization, which is reflected in industrial restructuring, green concept enhancement, biodiversity, ecosystem service function transfer, and it is also reflected in the overall improvement of the resource environment system. Exploring the coordination relationship between urbanization and resource environmental carrying capacity is conducive to a better understanding of the response of resource environmental carrying capacity to the urbanization process and the interaction between the two.

**Statistical Characteristics of the Coupling and Coordination Relationship**

Through correlation analysis, it was found that there was a significant positive correlation between urbanization and resource environmental carrying capacity in the Lanzhou-Xining urban agglomeration area from 2005 to 2017 ($R=0.506$, $P<0.01$ in 2005; $R=0.594$, $P<0.01$ in 2017). This indicated that the higher the level of urbanization, the higher the level of resource environmental carrying capacity to a certain degree. The correlation coefficient increased in the first two years, which means that the resource environmental carrying capacity has become closer to urbanization. Figure 4 showed the results of non-linear fitting of urbanization and resource environmental carrying capacity in 39 counties in the Lanzhou-Xining urban agglomeration in 2005. The goodness of fit passed the 1% significance test. This provides quantitative data support for comprehensively promoting urbanization to improve the comprehensive carrying capacity of large, medium and small towns and achieve coordinated development of human and land. However, urbanization and resource environmental carrying capacity do not have a strict linear relationship objectively, but a dynamic fluctuation system with non-linear, non-equilibrium, open interaction and self-organization ability. High-level urbanization areas may correspond to lower resource environmental carrying capacity. Conversely, some county areas with low urbanization levels have weak economic foundation, less land development and construction, and serious waste of resources, there are various contradictions and coercive forces in urbanization and resource environmental carrying capacity. At this time, it is necessary to coordinate the relationship between the two, and enhance the driving force of urbanization and the endogenous driving force of resource environmental carrying capacity.

![Figure 4](image)

**Figure 4.** The changes of resource environmental carrying capacity and coordination degree under different urbanization levels in 2005, 2017

The degree of coordination between urbanization and resource environmental carrying capacity was difficult to fully reflect with correlation analysis, and then the coordination degree model was used to explore the closeness between the two (Table 5). Table 5 showed that with the improvement of urbanization level, the coordination degree between urbanization and resource environmental carrying capacity in 2005 and 2017 showed an upward trend, while the coefficient of variation was decreasing year by year. It shows that with the improvement of urbanization level, urbanization and resource environmental carrying capacity are constantly harmonized, and coordination relationship...
divergence is becoming smaller. The fluctuations between 2005 and 2017 were relatively small and gradually stabilize. In the initial stage of urbanization, the development of water and soil resources was small, and the utilization rate of resources was low, the development was slow, the combination of water and soil resources was good, and the potential for space development was large. The urban population and industrial agglomeration have alleviated the pressure on resources and environment to a certain extent. So the degree of coordination between the two is higher. During the acceleration of urbanization, the central cities have experienced problems such as traffic congestion, rising land prices, resource shortages, and ecological and environmental pollution due to the rapid accumulation of population and economy. The limited carrying capacity of resources and environment has restricted the development of urbanization. The coordination degree of the two has declined compared with the level of urbanization in 2005. However, with the improvement of ecological civilization construction and environmental governance in recent years, the resource and environmental issues have been effectively controlled. The urbanization and resource environmental carrying capacity will develop in a coordinated manner as a whole.

Through the correlation analysis of urbanization level and coordination degree of Lanzhou-Xining urban agglomeration, it was found that the positive correlation between the two was significant (R=0.975, P<0.01), indicating that the higher the level of urbanization, the more coordinated the coordination degree between urbanization and the development of resources environmental carrying capacity. Figure 4b was the fitting results of the urbanization and the fit of the two of the Lanzhou-Xining urban agglomeration in 2017, and the goodness of fit passed the significance test of 1%. In the low-level urbanization stage, the coordination degree was low and the change was small. With the gradual improvement of the urbanization level, the coordination degree was rising in the fluctuation. Under the "One Belt, One Road" strategy, the urban economy has risen rapidly, attracting a large number of rural labor transfer. The rapid development of urbanization has brought pressure to the local ecological environment to a certain extent. The interaction between resource environmental carrying capacity and urbanization development level is more prominent. On the one hand, the rapid development of urbanization is bound to cause ecological environment problems. On the other hand, after the fragile ecological environment is damaged by pressure, to a certain extent, it limits the development speed and scale of cities and towns. For the Lanzhou-Xining urban agglomeration connecting the Silk Road Economic Belt and the Yangtze River Economic Belt, optimizing the utilization of resources and improving the quality of urbanization development is the key to achieving coordinated development of urbanization and resource environmental carrying capacity.

Table 5. Statistical characteristics of urbanization and coordination degree in different urbanization levels in 2005, 2017.

| Urbanization Level | Coordination Degree | 2005 | 2017 | 2017 |
|------------------|------------------|------|------|------|
|                  | Average Value    | Coefficient of Variation | Average Value | Coefficient of Variation |
| 0~0.2            | 0.4295           | 0.1086 | 0.4565 | 0.1070 |
| 0.2~0.4          | 0.5865           | 0.0810 | 0.5739 | 0.0631 |
| 0.4~0.5          | 0.6503           | 0.0608 | 0.6959 | 0.0411 |
| 0.5~0.8          | 0.6837           | 0.0476 | 0.7612 | 0.0184 |

Spatial Pattern Characteristics of Coordination Degree

In order to more intuitively reflect the spatial evolution characteristics of urbanization and resource environmental carrying capacity coordination degree in Lanzhou-Xining urban agglomeration, this paper was based on the coordination data of two time sections in 2005 and 2017 and made a regional study on the coordination degree with the help of ArcGIS platform, and obtained the temporal and spatial pattern distribution of coordination degree between them (figure 4, figure 5). On the whole, the coordination degree of urbanization and resource environmental carrying capacity of Lanzhou-Xining urban agglomeration in 2005-2017 was on the rise, and the spatial distribution law
of Lanzhou and Xining urban areas as the core and lowering to the outer circle counties was formed. The regional differences have gradually narrowed. The average of the coordination degree of urbanization and resource environmental carrying capacity of Lanzhou-Xining urban agglomeration in 2005 and 2017 was 0.50 and 0.55 respectively, which was in the reluctance coordination stage of (0.5, 0.6), and the number of medium and well-coordinated cities accounted for 35.90% of the total number of cities. The standard deviation of coordination degree in 2005 and 2017 was 0.101 and 0.113 respectively. The number of cities above the coordination average was 15 and 19 respectively, accounting for 38.46% and 48.72% of the number of units in the study unit. The urbanization and resource environmental carrying capacity coordination of 15 cities including Lanzhou District, Baiyin District, Pingchuan District, Anding District, Linxia City and Xining City were always higher than the average level, which was concentrated in the urban areas of Lanzhou-Xining urban agglomeration. The coordination degree of Chengguan District, Anning District, Xigu District, Honggu District and Chengxi District was second (0.7,0.8), and it was also in good coordination.9 counties such as Qilihe District, Gaolan County, Baiyin City, Anding District, Linxia City, and Chengdong District were moderately coordinated. The coordination degree of 10 counties such as Yongdeng, Yuzhong, Jingtai, Ping An and Ledu was between [0.5, 0.6], which was a reluctantly coordinated area. The number of close disorder areas had decreased from 19 counties in 2005 to 12 counties in 2017. The coordination degree of Dongxiang, Jishishan and Hualong County was between 0.3 and 0.4, and it was in a state of mild disorder.

Figure 5. The changes of the coordination degree between urbanization and resource environmental carrying capacity of counties and district of Lanzhou-Xining urban agglomeration in 2005-2017.

Figure 6. Spatial pattern and change of coordination index of between urbanization and resource and environment carrying capacity of Lanzhou-Xining urban agglomeration.
Conclusion and Discussion

Taking 39 counties in the Lanzhou-Xining urban agglomeration as an example, this paper analyzes the coordination status of urbanization and resource environmental carrying capacity in the Lanzhou-Xining urban agglomeration in 2005-2017 based on panel data and classifies the grades and types. It revealed the temporal and spatial pattern of coordination characteristics of these two systems, and mainly drew the following conclusions:

Since 2005, the comprehensive index of urbanization in the Lanzhou-Xining urban agglomeration has shown an upward trend, and the overall development trend was good, but the level of its economic subsystem needs to be improved. The high-level urbanization areas were mainly concentrated in the two provincial capital cities of Lanzhou and Xining. The low-level counties and districts were widely distributed and occupy a high proportion. The gap between the urbanization and the comprehensive level was large, and the radiation of the core cities of the entire urban agglomeration was insufficient. The comprehensive capacity of the resource and environment had been reduced first, and then maintained a steady and then slowly rose, which was the “U”-shaped curve. The overall spatial pattern was high in the east and low in the west, and high in the middle and low in the peripheral. The high-level space-bearing areas of the resource environment were concentrated in the districts of Lanzhou and Xining. The low-level areas were mainly concentrated in most counties and districts in Qinghai Province. There were certain spatial differences, which are related to the development process and resource and environmental basis of different regions.

With the improvement of urbanization level, the coordination degree of urbanization and resource environmental carrying capacity of Lanzhou-Xining urban agglomeration was generally on the rise. The interaction between subsystems was relatively close, and the positive correlation between urbanization and resource environmental carrying capacity was obvious. The regional differences in coordination degree were significant. The coordination degree of Lanzhou City, Xining City, Baiyin City, Linxia City and Anding District had been higher than the average level between 2005 and 2017, and it was in a better coordination state, while the counties with a low level of coordination had a high proportion and a concentrated distribution. There are multiple spatial coupling situations for urbanization, resource environmental carrying capacity and coordination between different levels of development in different regions. However, the level of urbanization and resource environmental carrying capacity development is better in the areas with higher economic development level.

Coordination development degree analysis as a relative index evaluation, the information reflected by the same coordination degree is not necessarily the same, and it needs to be comprehensively evaluated in combination with the actual development level status of urbanization and resource environmental carrying capacity of specific regions. The development gaps of counties and districts in the Lanzhou-Xining urban agglomeration are large. The urbanization level of a few counties is greater than the carrying capacity level. However, the overall level of urbanization is lower than the level of resource environmental carrying capacity in the same period. That is, under the guidance of the main function, Lanzhou-Xining Urban agglomeration has great potential for development and good carrying capacity, which means more development opportunities and upside opportunities.

As the core gathering area of economic and social development in Gansu and Qinghai Provinces, Lanzhou-Xining urban agglomeration is an important ecological barrier support area in western China, and an important urbanization area and a potential area for developing pillar industries to ensure the sustained development of the Silk Road Economic Belt. It plays an important role in promoting the development of the western region and ensuring ecological security in the northwest and even the whole country. The results show that the original urbanization development mode faces great pressures and contradictions. The level of economic development and urban development level are quite different, the polarization is obvious, the population of some areas is growing rapidly, and the demand for construction land is obviously increased. The environment is facing pressure to a certain extent, and the problem of regional development imbalance is more
prominent. With the transformation of new urbanization development, the urbanization level of the Lanzhou-Xining urban agglomeration area is rapidly increasing, and the development of resources and environment is also increasing. It is necessary to effectively control the population resources, the efficiency of land resource development and utilization, and accelerate the institutional mechanisms for the integration and integration of innovative urban agglomerations. Moreover, it is essential to accelerate the process of urban cluster contracting, coordinate the urban and rural spatial form and layout, improve the comprehensive carrying capacity of cities and towns and promote the spatial gathering of towns, industries and populations in urban agglomerations, and form an ecological urban cluster with harmonious urbanization and resource and environmental carrying capacity. It will drive the development of new urbanization in old industrial bases, poverty-stricken areas and ethnic areas.

Based on the development of the northwestern region, this paper uses the coupled coordination model to analyze the spatial and temporal changes of urbanization, resource environmental carrying capacity and coordination relationship. However, the current definition of the urbanization and resource environmental carrying capacity of urban agglomerations and the construction of the indicator system is still a question worthy of discussion in the academic world, and it is necessary to carry out comprehensive and in-depth research in future.

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