Evaluation on Spatial of National Land Development Pattern of Lanzhou-Xining Urban Agglomeration Based on Resource and Environment Carrying Capacity

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Abstract. The analysis of spatial of national land development pattern is of great significance for optimizing the layout of spatial of national land development and realizing regional sustainable development. The comprehensive evaluation on spatial of national land pattern of Lanzhou-Xining urban agglomeration can deepen the scientific cognition of rational spatial of national land development of regional urban agglomeration and provides a theoretical basis for space governance. Based on the actual situation of Lanzhou-Xining urban agglomeration, this paper analyzed the carrying capacity of resource and environment in counties and districts, clarified the spatial difference of carrying capacity of resources and environment, and proposed the characteristics of land development pattern of Lanzhou-Xining urban agglomeration. As shown by the results, the spatial pattern of the natural carrying capacity index is distinctly different, showing a decreasing trend from the study area center to the periphery and also from the east to the west; High carrying capacity potential areas are mainly concentrated in Lanzhou, Xining and their surrounding counties; the spatial difference in the comprehensive index of resource and environment carrying capacity is large, and the contribution of natural carrying capacity to the resource and environment carrying capacity is higher, the spatial distribution of high value area is more discrete, and the spatial distribution of low value area has obvious agglomeration characteristics.

1. Introduction
The report of the 18th NCCPC promoted the optimization of spatial of national land development pattern as the primary task of ecological civilization construction so that the long-term research direction of economic geography that reveals the earth surface economic geographical process and formation and evolution law of spatial of national land development pattern has entered a new stage (Fan, 2013). The spatial of national land development pattern is regarded as the distribution state of economic factors formed by long-term production and management activities. With the rapid development of industrialization and urbanization, the land use structure and mode are out of control, the regional development is in disorderly competition, the environmental quality declines and the ecological environment deteriorates, which has a significant impact on the spatial of national land structure and landscape pattern and restricts human survival and sustainable development as well as social and economic harmony and stability. Understanding the characteristics of China’s spatial of national land development pattern and space coupling relationship is the key to define and solve the above problems as well as the foundation to follow the characteristics of China’s land resource structure, economic and social layout and ecological security pattern and realize regional coordination and sustainable development (Li, 2017).
The evaluation of spatial of national land development pattern has always been one of the important areas of academic concern, and this paper mainly reviews the relevant literature from the perspective of resource and environment carrying capacity. The concept, theory, method and application of resource and environment carrying capacity gradually kick off with the emergence of sustainable development idea. The system dynamics model plays an important role in the theoretical analysis of the concept of resource and environment carrying capacity (Liu, 2013). The single factor carrying capacity calculation based on global, national and regional scales is the main research content of application practice of resource and environment carrying capacity, such as ecosystem carrying capacity, land resource carrying capacity, water resource carrying capacity, environment carrying capacity and urban carrying capacity (Ma et al., 2017; Mondino et al., 2014; Ait-Aoudia and Berezowska-Azzag, 2016; Hui, 2015; Tehrani and Makhdoum, 2013). As can be seen from the existing research, the research on the resource and environment carrying capacity focuses on the analysis of single factor carrying capacity rather than comprehensive carrying capacity. Therefore, to evaluate spatial of national land development pattern of Lanzhou-Xining urban agglomeration based on resource and environment carrying capacity, on the one hand, it can enrich the research content system, broaden the research area, on the other hand, it can deepen the scientific cognition and theoretical research on land development of regional urban agglomeration.

The Lanzhou-Xining urban agglomeration is the most densely populated area and with relatively good economic foundation in Hehuang area, which taking the Yellow River and huangshui as the link, Lanzhou and Xining is the center. Based on geographical proximity and accessibility of traffic, the Lanzhou-Xining urban agglomeration forms the only geographical unit with watershed characteristics and relatively complete in the western region. Because of its special geographical conditions and economic base, The Lanzhou-Xining urban agglomeration occupies an important position in the development pattern of western land space, and its strategic position has been greatly improved especially in the context of the era of economic globalization and regional collectivization and the construction of "One Belt And One Road". This paper takes county administrative region as the basic unit, by analyzing the characteristics of national land space pattern, and discussing the existing problems in the process of urbanization of Lanzhou-Xining urban agglomeration, in order to provide a new theoretical framework for urban land use planning, infrastructure construction and environmental protection planning, at the same time, it provides scientific basis for spatial development pattern optimization and sustainable development of Lanzhou-Xining urban agglomeration under the guidance of the silk road economic belt and the national regional development strategy.

2. Study Area

Lanzhou-Xining urban agglomeration is located in the eastern part of the Qinghai-Tibet region, with administrative division ranging from 98°05′E-105°38′E, 34°07′N-39°05′N. Its main body includes Lanzhou-centered area with dense towns in Gansu Province and Xining-centered area with dense towns in Qinghai Province. According to the literature research, there is much research on Lanzhou-Xining urban agglomeration, and the state has proposed to cultivate Lanzhou-Xining urban agglomeration in various plans and outlines, but the specific administrative units have not been unified. Jia (2013) defined the spatial range of Lanzhou-Xining urban agglomeration by virtue of gravity model. Fang et al. (2016) pointed out in the China Urban Agglomeration Development Report that the range of Lanzhou-Xining urban agglomeration urban agglomeration should include Lanzhou, Baiyin, Xining, Dingxi, Linxia and Haidong. Because Hehuang area is the basic carrying area of Lanzhou-Xining urban agglomeration, this paper Combining with the natural geographical environment of Hehuang area from the perspective of geographical proximity and integrity, based on the definition of the spatial scope of Gansu and Qinghai province about Lanzhou-Xining urban agglomeration prophase research, defined the range of Lanzhou-Xining urban agglomeration as large Hehuang area (Fig.1), which covers 53 counties (districts) of Gansu and Qinghai, such as Lanzhou(including Lanzhou New District), Baiyin, Dingxi, Linxia Prefecture, Tianzhu County, Hezuo, Xiahe County, Lintan County, Zhuoni County, Xining, Haidong, Menyuan County, Haiyan County, Qilian County, Gonghe County, Guide County, Tongren County, and Jianzha County. The total area of the study area is 155,700 km².
including 85,200 km² in Gansu, accounting for 18.78% of the land area of Gansu and 72,300 km² in Qinghai, accounting for 10.03% of the land area of Qinghai.

![Location of the Study Area](image_url)

**Figure 1.** Location of the Study Area

### 3. Materials and Methods

#### 3.1. Data

DEM data were GDEMDEM 30m resolution digital elevation data from the DEM database of GSCloud Geospatial data cloud (http://www.gscloud.cn/) of the Chinese Academy of Sciences. Meteorological data were from the China Ground Normal Dataset (1981-2010) of China Meteorological Data Network (http://data.cma.cn). Traffic data were from the China Traffic Atlas (2016). GIS technology was used to digitalize the comprehensive road map of Gansu and Qinghai and overlay the areal map of the study area to get the road traffic map of Lanzhou-Xining urban agglomeration. Social and other data were from Gansu Statistical Yearbook (2016), Qinghai Statistical Yearbook (2016), Gansu Water Resources Bulletin (2016), Qinghai Water Resources Bulletin (2016), National Major Function Oriented Zoning, Gansu Major Function Oriented Zoning, Qinghai Major Function Oriented Zoning and other related statistics and planning information.

#### 3.2. Methods

**3.2.1. Construction of Evaluation Index System.** Due to the factors affecting the resource and environment carrying capacity of urban agglomeration are complex and diverse, the index system of comprehensive measure should be scientifically reflect the urban agglomeration area social economy, resources, environment and spatial structure characteristics (Liu, 2013). In this paper, the resource support index, environmental capacity index, agglomeration degree index, financial capacity index and concordant level index are selected as the criterion layer, among them, the first three factors are the direct factors that determine the resource and environment carrying capacity of urban agglomeration, and the latter two are the indirect influencing factors (Table 1).
Through the standardized treatment of each index of resource and environment carrying capacity, the combination of AHP and entropy weight method was used to determine the weight of each evaluation index comprehensively (Li, 2014). Based on the practice of Lanzhou-Xining city agglomeration, the classification threshold of single factor classification is divided into 5 levels based on professional knowledge classification and GIS natural breakpoint classification. The specific classification scheme is shown in table 2. On the basis of single factor analysis of the factor layer, the weighted sum method is used to carry out level-by-level merge and integration, and the evaluation results of indexes of each criterion layer are obtained successively. The calculation formula is as follows:

\[ d_i = \sum_{j=1}^{m} x_{ij} w_j \times 10 \]  

Where: \( d_i \) is the cell merge value of each index in the criterion layer; \( m \) is the index number of the next level contained by each index of the criterion layer; \( w_i \) is the weight of the index \( i \); \( x_{ij} \) is the standardized value of the index \( i \).

### Table 1. The Index System of Resources and Environment Carrying Capacity of the Lanzhou-Xining Urban Agglomeration

| System layer       | Criterion layer                        | Index layer                                | Nature | Weight |
|--------------------|----------------------------------------|--------------------------------------------|--------|--------|
| Resource support   | Available land resource(10^4km²)        | +                                          | 0.220  | 0.109  |
| Environmental      | Utilizable water resources(10^3m³)      | +                                          | 0.109  | 0.111  |
| capacity           | Air environmental capacity             | +                                          | 0.340  | 0.170  |
| Resources          | Water environmental capacity           | +                                          | 0.170  |        |
| and environment    | Population density(people/km²)         | +                                          | 0.070  |        |
| environment        | Industry concentration                | +                                          | 0.080  |        |
| carrying capacity  | Urban density                         | +                                          | 0.053  |        |
|                    | Traffic network accessibility          | -                                          | 0.008  |        |
| Financial capacity | Per capita GDP growth rate             | +                                          | 0.053  |        |
| Concordant level   | The intensity of spatial interaction   | +                                          | 0.144  |        |
|                    | The similarity of industrial structure | -                                          | 0.060  |        |

### 3.2.2. Carrying Capacity Measure Model

Resource and environment carrying shows a certain ladder effect, so according to the difference of the mechanism and influence degree, the resource and environment carrying capacity of urban agglomeration can be understood as the coupling of natural carrying capacity and potential carrying capacity. Natural carrying capacity is the urban agglomeration determined by the attribute of the natural system of resource and environment in the urban agglomeration, while potential carrying capacity is obtained under the influence of social factors in the urban agglomeration. The specific calculation model is as follows:

1. Natural carrying capacity model

\[ N = (1 - k) \cdot \alpha^2 \cdot e^\beta \]  

Where, \( N \) for the urban group natural carrying capacity index; \( k \) for the limiting factor coefficient \((0 \leq k \leq 1)\), it mainly refers to the restrictive natural conditions which affect resources and environment carrying capacity, such as terrain, slope, etc.; \( \alpha \) for the resource support index; \( \beta \) for the environmental capacity index.

2. Carrying capacity potential model
\[ F = \mu \cdot \delta \cdot e^{Con} \]  

(3)

Where, \( F \) is potential index of carrying capacity of urban agglomeration; \( \mu \) is economic capacity index; \( \delta \) is agglomeration degree index; \( Con \) is integration level index.

(3) Comprehensive carrying capacity model of resource and environment

\[ RECCC = N \cdot e^F \]  

(4)

Where, \( RECCC \) is comprehensive index of resource and environment carrying capacity of urban agglomeration.

Table 2. Partitioning Method of Threshold Interval of the Single Factor Classification of the Lanzhou-Xining Urban Agglomeration

| Index                        | I     | II    | III   | IV    | V     | VI     |
|------------------------------|-------|-------|-------|-------|-------|--------|
| Available land resource      | 0-286 | 287-699 | 700-1747 | 1748-4287 | 4288-7819 |
| Utilizable water resources   | 0.001-0.20 | 0.204-0.49 | 0.493-0.8 | 0.895-3.03 | 3.032-4.721 |
| Air environmental capacity   | 3     | 2     | 94    | 1     |       |        |
| Water environmental capacity | 1     | 2     | 3     | 4     | 5     |        |
| Population density           | 0-150 | 151-500 | 501-2000 | 2001-3000 | 3001-9566 |
| Industry concentration       | 0.001-0.05 | 0.054-0.16 | 0.164-0.3 | 0.368-0.56 | 0.570-4.998 |
| Urban density                | 0.029 | 0.030-0.05 | 0.060-0.1 | 0.112-0.36 | 0.364-0.123 |
| Traffic network accessibility| 144-165 | 166-187 | 188-220 | 221-278 | 279-425 |
| Per capita GDP growth rate   | 0.907-0.96 | 0.969-1.02 | 1.028-1.10 | 1.095-1.16 | 1.162-1.273 |
| The intensity of spatial interaction | 1-103 | 104-395 | 396-1049 | 1050-8547 | 8548-28060 |
| The similarity of industrial structure | 0.636-0.73 | 0.732-0.79 | 0.794-0.8 | 0.842-0.86 | 0.867-0.889 |

4. Results and Discussion

According to the criterion layer results of resource and environment carrying capacity, the natural carrying capacity index, carrying capacity potential index and comprehensive carrying capacity index of resource and environment were calculated respectively. The spatial classification of carrying indexes of each county was carried out with the natural breakpoint method in ArcGIS10.2, as shown in Figure 2.

The spatial pattern of the natural carrying capacity index is distinctly different, showing a decreasing trend from the center to the periphery and also from the east to the west (Figure 2a). The highest value 16.634 is distributed in Linxia City, Gansu, followed by Baiyin District, Gansu (10.081), Pingchuan County, Gansu (8.541), Lintan County, Gansu (7.626), Longxi County, Gansu (7.476) and Chengbei District, Qinghai (7.677). The above counties because of its better resource and environment base, such as better geological and geomorphologic conditions, rich reserved land resources and adequate development and utilization of water resources. The higher value counties are irregularly distributed in the periphery of the highest counties, mainly including the core areas and surrounding counties of Hehuang Valley, represented by Lanzhou and Xining, the natural carrying capacity index is between 2.044–5.232. They have better geographical environment and natural resource base, high degree of economic and social development, and relatively abundant available soil and water resources. The most counties in Qinghai and Linxia, Gannan, individual county area of Dingxi in Gansu, are the
low value distribution areas of the natural carrying capacity index of Lanzhou-Xining urban agglomeration, mainly due to the natural conditions are more limited or the per capita available water and soil resources are low.

High carrying capacity potential areas are mainly concentrated in Lanzhou, Xining and their surrounding counties (Figure 2b), and Chengguan District, Lanzhou has the highest value 2.712, followed by Chengxi District (2.125) and Chengzhong District (1.795), Xining. Second high value areas include Qilihe District and An’ning District, Lanzhou, Chengdong District and Chengbei District, Xining, the carrying capacity potential index is between 0.393 and 1.042. The above cities have higher agglomeration index and integration level index, indicating better regional division of labor and factor mobility, stronger ability of social and economic regulation, and higher potential of resource and environment carrying capacity. Gaolan County, Linxia City, Linxia County, Datong Tu Autonomous County, and Huangzhong County belong to the middle level (0.095 ~ 0.392), with better social and economic development and certain self-regulation ability. The low potential areas are mainly concentrated in the surrounding counties of the study area, with better natural resource base but low level of social and economic development, far distance from the provincial capitals of Lanzhou and Xining, poor mobility of resource and socio-economic factors and it is difficult to undertake the radiation and driving effect of Lanzhou and Xining.

The comprehensive index of resource and environment carrying capacity has large spatial difference, Chengguan District, Gansu has the highest value 51.397, and Qilian County, Qinghai has the lowest value 0.004, and it shows low spatial dispersion degree and obvious spatial clustering feature (Figure 2c). High value areas include Chengguan District and Linxia City, Gansu, Chengxi District, Chengbei District and Chengzhong District, Qinghai, the comprehensive index of resource and environment carrying capacity is between 12.298 and 51.397. They have high natural carrying capacity index and large improvement space of potential index, and some counties have higher economic and social development, so the resource and environment have higher comprehensive carrying capacity for the production capacity of residents. The middle level (5.256 ~ 12.297) mainly includes An’ning District, Baiyin District, Pingchuan District, Longxi County, Gansu, Chengzhong District, Chengdong District, etc. Their resources endowment condition is good, water and soil resources are relatively abundant, economic and social development has less pressure on local resources and environment. Areas with low carrying capacity of resource and environment (0.004 ~ 5.255) are mainly distributed in most of the county of Qinghai province (except Xining Municipal Districts) and LinXia, Gannan, Dingxi and Baiyin, etc. It is mainly due to the low natural carrying capacity and high carrying capacity potential lead to the low carrying capacity of resource and environment. In general, the contribution of natural bearing capacity to the capacity of resources and environment is higher. Most counties in low value area have strong bearing capacity for economic development pressure; however, due to its low economic and social radiation capacity and input intensity, the resource environment carrying capacity is low.
5. Conclusions

The evaluation results of the carrying capacity of resources and environment basically reflect the spatial differences of the carrying capacity of human beings and social economy under the background conditions of resources and environment in the research area, providing a theoretical basis for realizing the sustainable utilization of land resources and promoting the coordinated development of land space development and resources and environment. As shown by the results, the spatial pattern of the natural carrying capacity index is distinctly different, showing a decreasing trend from the center to the periphery and also from the east to the west; High carrying capacity potential areas are mainly concentrated in Lanzhou, Xining and their surrounding counties; The comprehensive index of resource and environment carrying capacity has large spatial difference, and the contribution of natural bearing capacity to the size of resource and environment carrying capacity is higher, the spatial distribution of high value area is more discrete, and the spatial distribution of low value area has obvious agglomeration characteristics.

As in Lanzhou-Xining urban agglomeration development plan for approval and implementation, the strategic position of Lanzhou-Xining urban agglomeration is further improved, and its national spatial structure pattern of stability and security become maintain the important foundation of the development and prosperity of the northwest region. Due to national spatial land involves the natural and social economic factors such as the land resource, water resources, ecological environment, population, transportation and industry and so on, it can reflect the interaction and interrelation between land type and function in a certain region. On the basis of integrating the corresponding factors, this paper makes a analysis of the spatial pattern of the study area from the resource and environment carrying capacity aspects, and clarified the present situation and characteristics of national land space development pattern in the research area. It provides a new way to evaluate the spatial pattern of other urban agglomerations. However, due to the limitations of cognitive level and basic data, there is no in-depth analysis of the internal relations between all factors, which will be the direction of the research in the future.

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7. References

[1] Fan J, Zhou K, Chen D. 2013. Innovation and Practice of Economic Geography for Optimizing Spatial Development Pattern in Construction of Ecological Civilization. Economic Geography, 33(1):1-8. (in Chinese)

[2] Li J, Zhang X J, Liu L M, et al. 2013. Land Pattern and Process Analysis in Dongchuan, Kunming from 1990 to 2010. Journal of Yunnan Agricultural University (Natural Science), 32(2): 342-349. (in Chinese)

[3] Liu X L. 2013. Theory and Practice of Resources and Environment Carrying Capacity of City Clusters. Beijing: China Economic Publishing House, 27-30. (in Chinese)

[4] Ma P, Ye G, Peng X, et al. 2017. Development of an index system for evaluation of ecological carrying capacity of marine ecosystems. Ocean & Coastal Management, 23-30.

[5] Mondino E B, Fabrizio E, Chiabrando R. 2014. A GIS Tool for the Land Carrying Capacity of Large Solar Plants. Energy Procedia, (48):1576-1585.

[6] Ait-Aoudia M N, Berezowska-Azzag E. 2016. Water resources carrying capacity assessment: The case of Algeria's capital city. Habitat International, (58):51-58.

[7] Hui C. 2015. Carrying Capacity of the Environment. International Encyclopedia of the Social & Behavioral Sciences, (3):155-160.

[8] Tehrani N A, Makhdoum M F. 2013. Implementing a spatial model of Urban Carrying Capacity Load Number (UCCLN) to monitor the environmental loads of urban ecosystems. Case study: Tehran metropolis. Ecological Indicators, 32(9):197-211.

[9] Jia Z. 2013. Industry Evolution and Path Optimization of Urban Agglomeration in Western China. doctoral dissertation. Lanzhou: lanzhou university, 31-33. (in Chinese)

[10] Fang C L, Bao C, Ma H T. 2016. Report on development of urban agglomeration in China. Beijing: Science Press, 257-262. (in Chinese)

[11] Li S, Wei H, Ni X L, et al. 2014. Evaluation of urban human settlement quality in Ningxia based on AHP and the entropy method. Chinese Journal of Applied Ecology, 25(9):2700-2708. (in Chinese)