

Analysis on Spatial and Temporal Evolution Characteristics of National Land Structure of the Lanzhou-Xining Urban Agglomeration in the Upper Reaches of the Yellow River

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Abstract. Based on the land utilization data of the Lanzhou-Xining urban agglomerations in 2000, 2005, 2010 and 2015, using the methods of transfer matrix, the paper makes a quantitative analysis of the spatial and temporal evolution process, characteristics and laws of various types of national land space from 2000 to 2015. The results are as follows. 1) Urban construction space, industrial and mining construction space and rural living space continued to increase, while agricultural production space showed a decreasing trend, and green ecological space and other ecological space showed an overall increasing trend from 2000 to 2015. 2) The characteristics of national land space transfer are as follows: the transition is relatively active from 2000 to 2005 and from 2010 to 2015, mainly from green ecological space and agricultural production space to urban construction space, rural living space and industrial and mining construction space.

1 Introduction

Urbanization is the process of population concentration in cities and towns and thus promotes the development of cities and towns [1], and it is also the inevitable outcome of the development of industrialization to a certain stage. As the main form of urbanization and an important carrier of modernization construction, urban agglomeration gathers important resources, industries and economy in specific regions, and becomes a key regional spatial form to realize the intensive utilization of regional spatial resources and promote the sustainable development of urbanization in the new era. Land resources are the material basis and carrier space for urbanization development, and will inevitably be largely occupied with the rapid advancement of urbanization [2]. Due to the spread of urban land, the land use efficiency is low and the ecological environment gradually deteriorates, thus affecting the quality of China's urbanization development and the healthy operation of the economy [3]. Unreasonable land use structure and methods, deterioration of environmental quality and deterioration of the ecological environment in the process of urbanization, will inevitably have a significant impact on the structure and landscape pattern of territorial spatial development, which restricts the sustainable development of human existence and the harmony and stability of social economy. However, urban agglomeration construction is an effective urbanization mode to solve the disorderly development of land space under the background of rapid urban development.

Connecting the spatial structure of land and land use/land cover change is a new perspective to study the spatial evolution of land. The spatial pattern of land use

and its dynamic evolution have always been the focus and hot issue of geography, land use science and ecology. With the strengthening of global consciousness and system concept, many scholars have carried out research on land use in different regions by using different methods, models and software from different angles. Topics and models specially used for the study of land use and spatial pattern have been formed abroad [4-5]. With the rapid development of multi-temporal and multi-resolution aerial and aerospace remote sensing sensors, it provides a solid data basis for multi-scale spatial land use change process monitoring [6]. The comprehensive development of remote sensing, geographic information system and global positioning system has become the technical guarantee for the study of land use/land cover change [7-8]. Domestic scholars in time tracking the international trend of land use/land cover research, from the land cover change mechanism, the mechanism of land use change and regional and national land use survey in three key areas, mainly includes the dynamic process of land use change, driving factors and the analysis of the driving mechanism and ecological environment effect [9-14]. In general, the evaluation methods and contents of land use change are diverse at home and abroad, but there are few studies on the characteristics of spatial-temporal pattern evolution based on the carrier of territorial space.

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

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western region. Because of its special geographical conditions and economic base, the sustainable development and regional coordination of the Lanzhou-Xining urban agglomeration have always been the focus of the whole society. From the perspective of realizing the goal of land space development and promoting the formation of main functional zones, this study divides the land space of Lanzhou-Xining Urban Agglomeration into three types: urban space, agricultural space and ecological space. With the help of ArcGIS10.2 software platform, the spatiotemporal evolution process, characteristics and laws of different kinds of land space in the study area from 2000 to 2015 were quantitatively analyzed by using the models and methods such as dynamic attitude of land space and transfer matrix. Therefore, the temporal and spatial evolution characteristics of land spatial structure in Lanzhou-Xining City Agglomeration region under the background of rapid urbanization are revealed, which provides a foundation for further research on urban sustainable development.

2 Study area

The Lanzhou-Xining Urban Agglomeration is located in the upper reaches of the Yellow River, between the ecological barrier of the Qinghai-Tibet Plateau and the sand control belt in northern China, its main body includes the relatively dense urban areas in Gansu Province with Lanzhou as the core and the relatively dense urban areas in Qinghai Province with Xining as the core. The population of this region is relatively dense, and the water and soil resources are relatively good, which plays an irreplaceable role in maintaining the overall situation of national security and ecological security in China. Since Hehuang area is the basic bearing area of Lanzhou-Xining City Agglomeration, this study combined with the natural geographical environment of Hehuang area, From the perspective of geographical proximity and integrity, on the basis of referring to the spatial scope of preliminary research of Gansu Province and Qinghai Province on Lanzhou-Xining City Agglomeration Planning and the administrative division scope of Lanzhou-Xining City Agglomeration Development Plan approved by the State Council in February 2018, defined the range of Lanzhou-Xining urban agglomeration as large Hehuang area, 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.

3 Materials and methods

3.1 Data

The data of land use in the study area came from the Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences(<http://www.resdc.cn>). Including 1 km raster remote sensing monitoring data generated from 1:100,000 scale vector data grid in 2000, 2005, 2010 and 2015, and there are 6 primary land use types and 25 secondary land use types. Because the different land space has the different natural background condition, the different main body function and the different development way. According to the National Plan for Functional Zones -- Building an Efficient, Coordinated and Sustainable Development Pattern of Territorial Space, the Plan for Functional Zones of Gansu Province and the Plan for Functional Zones of Qinghai Province, space of national land can be divided into different types from the Angle of development mode, development content, main function and product supply, and the reflection of each kind of space in the development of space of national land constitutes the structure of space of national land. From the perspective of promoting the formation of main functional areas, combining with the land use remote sensing image interpretation data of the study area, the land space of Lanzhou-Xining Urban Agglomeration was divided into urban space, agricultural space and ecological space. Among them, urban space includes urban construction space and industrial and mining construction space, agricultural space includes agricultural production space and rural living space, ecological space includes green ecological space and other ecological space.

3.2 Methods

3.2.1 Analysis method of national land spatial structure change

(1) Range of change in the national land spatial structure

$$U_{b-a} = U_b - U_a \quad (1)$$

$$U = (U_b - U_a) / T \quad (2)$$

Where: U_{b-a} is the overall range of change; U is the annual mean range of change; U_a is the initial number of a certain type of land space; U_b is the final number; T is the time span.

(2) Speed of change in the national land spatial structure

①Single national land space dynamic degree

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \quad (3)$$

Where: K is the dynamic degree of the spatial types of a single national land in the study period.

② Comprehensive dynamic degree of national land space

$$LC = \frac{\sum_{i=1}^n \Delta LU_{i-j}}{2 \sum_{i=1}^n LU_i} \times \frac{1}{T} \times 100\% \quad (4)$$

Where: LC is the Comprehensive dynamic degree of national land space; LU_i is the national spatial area of class i land at the starting time; ΔLU_{i-j} is the absolute value of area transformed from category i national land space to other types in the research period.

3.2.2 The transition matrix of national land space

The mathematical expression was as follows:

$$S_{ij} = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ S_{n1} & S_{n2} & \cdots & S_{nm} \end{bmatrix} \quad (5)$$

Where: S_{ij} is the state of national land space at the beginning and the end of the research; n is the number of national land space types.

4 Results and discussion

4.1 Characteristics of dynamic change of national land spatial structure

Combined with the interpretation data of remote sensing images of land use in 2000, 2005, 2010 and 2015, the land spatial use status maps of the four periods in the study area were obtained by using the reclassification method in ArcGIS10.2 (Fig.1), and the area changes of different national land spatial types in four periods were respectively counted (Table 1). Based on this, the paper analyzes the change process of spatial distribution of different types of national land in different periods in the study area. In terms of spatial distribution, the proportion of green ecological space in the study area is more than 72% in the whole study period, that is, the main space of the study area is green ecological space. The agricultural production space occupies the second place in the study area, with a proportion of about 18% in each period. Next is other ecological space, area proportion is above 8% in each period. The areas of urban construction space, industrial and mining construction space and rural living space are roughly the same, and the total proportion of the three kinds of national space is less than 2%, and the overall proportion of this relationship changes little in the four years.

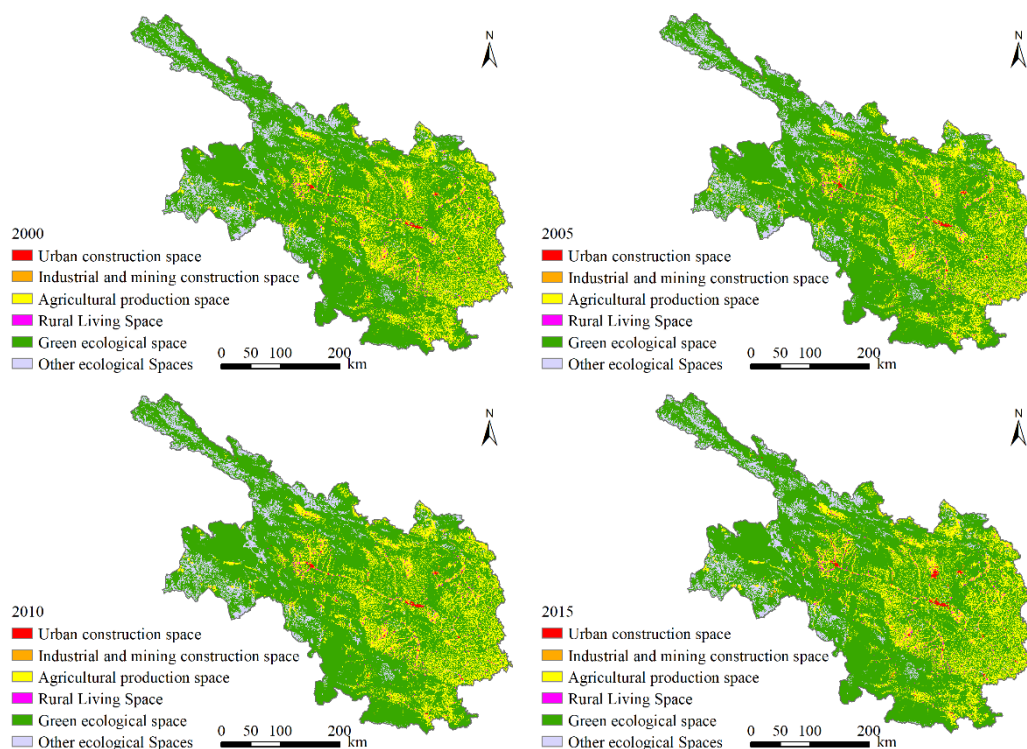


Figure 1. Current situation map of national land space utilization in different periods in Lanzhou-Xining urban agglomeration area.

Table1. The quantity variation of national land spatial structure in different periods in Lanzhou-Xining urban agglomeration area.

	Year	Urban construction space	Industrial and mining construction space	Agricultural production space	Rural Living Space	Green ecological space	Other ecological Spaces
Area Percentage (%)	2000	0.17	0.06	18.39	0.94	72.34	8.10
	2005	0.20	0.06	18.13	0.97	72.52	8.12
	2010	0.21	0.06	18.10	0.97	72.53	8.13
	2015	0.32	0.15	17.91	1.05	72.45	8.13
Range of change (km ²)	U ₀₀₋₀₅	55	3	-395	37	271	29
	U ₀₅₋₁₀	8	5	-49	5	20	11
	U ₁₀₋₁₅	168	129	-293	131	-129	-6
	U ₀₀₋₁₅	231	137	-737	173	162	34
	U	15.40	9.14	-49.14	11.54	10.80	2.67
Single type dynamic degree (%)	K ₀₀₋₀₅	4.23	0.67	-0.28	0.51	0.05	0.05
	K ₀₅₋₁₀	0.51	1.08	-0.04	0.07	0.00	0.02
	K ₁₀₋₁₅	10.4	26.33	-0.21	1.76	-0.02	-0.01
	K	5.92	10.15	-0.17	0.80	0.01	0.02

In terms of the range of change, the spatial changes of various types of national land were relatively stable from 2000 to 2015. The space for urban construction, industrial and mining construction and rural living space continues to increase, while the space for agricultural production shows a decreasing trend, and the green ecological space and other ecological space show an overall increasing trend. Urban construction space and rural living space increased considerably, the average annual added value is 15.40 km² and 11.54 km²; The second is green ecological space and industrial and mining construction space, with an average annual added value of 10.80 km² and 9.14km². In terms of the total amount change, the area and range of the largest change was agricultural production space, which decreased by 737 km²; The second is urban construction space, with an increased area of 231km². The reason is mainly due to the influence of rapid urbanization, the rapid urban expansion, the obvious expansion of built-up areas, occupy a large number of arable land and basic farmland.

According to the dynamic degree model of the single national land space, the K values reflecting the changes of different national land space in different periods are calculated. From the average level, except for the negative annual dynamic degree of agricultural production space, all other types of national land space are positive. The average annual dynamic degree of agricultural production space was -0.17%, which showed a decreasing trend. Urban construction space and industrial and mining construction space increased significantly, with an average annual dynamic degree of 5.92% and 10.15%, this indicates that the increase of other construction land is obvious and the development intensity of national land space is great. The calculation results of comprehensive dynamic degree in territorial space show that it is 0.044% from 2000 to 2005, 0.012% from 2005 to 2010, and 0.048% from 2010 to 2015. This indicates that the change of territorial spatial structure has been relatively slow since 2000, but the overall change of territorial spatial structure has been improved since 2010.

Table2. National land transfer matrix of Lanzhou-Xining urban agglomeration(km²).

Period	Pattern	UCS	ICS	APS	RLS	GES	OES	Roll-out
2000-2005	UCS	260	0	0	0	0	0	0
	ICS	7	83	0	0	0	0	7
	APS	28	7	27836	47	388	29	499
	RLS	11	0	2	1433	4	0	17
	GES	9	3	102	6	111328	14	134
	OES	0	0	0	1	13	12471	14
	summation	55	10	104	54	405	43	671
2005-2010	UCS	315	0	0	0	0	0	0
	ICS	0	93	0	0	0	0	0

	APS	4	4	27844	10	78	0	96
	RLS	3	0	0	1481	3	0	6
	GES	1	1	44	1	111665	21	68
	OES	0	0	3	0	7	12504	10
	summation	8	5	47	11	88	21	180
2010-2015	UCS	322	0	0	0	1	0	1
	ICS	1	97	0	0	0	0	1
	APS	120	40	27535	119	44	33	356
	RLS	4	1	3	1483	1	0	9
	GES	44	81	52	21	111485	70	268
	OES	0	8	8	0	93	12416	109
	summation	169	130	63	140	139	103	744

Annotation: UCS stands for urban construction space; ICS stands for industrial and mining construction space; APS stands for agricultural production space; RLS stands for Rural Living Space; GES stands for green ecological space; OES stands for other ecological Spaces.

4.2 Spatial transformation of national land spatial structure

According to the Markov transfer matrix model, the raster calculator in ArcGIS10.2 software was used to analyze the remote sensing data of the study area, and the spatial change transfer matrix of the study area was obtained (Table 2). It can be seen that, the conversion range of national land space types in the study area was small from 2000 to 2015. Green ecological space and agricultural production space had the largest transfer area, and the main transfer direction was urban construction space, rural living space and industrial and mining construction space, while the transfer area of other types of national land space was small. According to the transformation of different types of national land space, the spatial differentiation characteristics of national land space change in different periods in the study area were analyzed. The change of spatial structure of national land was relatively active from 2000 to 2005, and the conversion area of agricultural production space to green ecological space was relatively large, which was mainly distributed in Anding District, Weiyuan County, Zhang County, Min County and Tongren County. The spatial transformation of national land is not obvious during 2005-2010, and it is difficult to effectively identify the degree of spatial agglomeration in this period. From 2010 to 2015, the area of agricultural production space converted into urban construction space and rural living space was relatively large. The urban construction space is mainly distributed in Yongdeng County and Gaolan County, namely the new district of Lanzhou, while the rural living space is mainly distributed in Huangzhong County and Chengbei District.

5 Conclusions

Economic development is inevitably accompanied by changes in spatial structure. As an important material basis to reflect economic structure, the evolution process and pattern characteristics of national land spatial structure have important influence on the transformation of

development mode, optimization of resource allocation and realization of sustainable development. This study systematically analyzed the evolution characteristics of land spatial structure in Lanzhou-Xining Urban Agglomeration, and the results showed that: (1) In terms of quantity change, the main space of the study area is green ecological space, and the changes of all kinds of national land space are relatively stable during the whole study period. The space for urban construction, industrial and mining construction and rural living space continues to increase, while the space for agricultural production shows a decreasing trend, and the green ecological space and other ecological space show an overall increasing trend. From the perspective of time, the change rate was relatively slow from 2000 to 2010, and the overall change of national land spatial structure improved after 2010. (2) In terms of the transfer direction, the transfer was relatively active during 2000-2005 and 2010-2015, and almost stagnated during 2005-2010. The large transfer area was mainly green ecological space and agricultural production space, and the main transfer direction was urban construction space, rural living space and industrial and mining construction space.

As in Lanzhou-Xining urban agglomeration development plan for approval and implementation, and the promotion of "ecological protection and high-quality development of the Yellow River Basin" as a major national strategy, 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. Focusing on the development of land resources into the main functional area, this paper analyzes the spatial-temporal variation characteristics of the national land spatial structure in the study area, and provides a new perspective for the research on the evolution of the land

spatial pattern of other urban agglomerations. However, due to the limitations of cognitive level and basic data, we did not analyze the evolution characteristics and internal mechanism of territorial spatial structure in combination with other factors. This will be the next research plan.

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