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Study on the Dynamic of the Land Using Based on the RS and GIS Techniques

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Abstract

Land Use/Cover Change (LUCC) is an important part and core content of global environmental change; it has great significance for the regional sustainable development and regional land management. RS and GIS are of very prominent advantages in the study of macro land use, in recent years, both the scope and depth of the study on regional land use change based on RS and GIS method had great enhancement. This thesis will use the TM satellite remote sensing images of 3 different time phases as the main source of data, the author, based on RS and GIS, will interpret and extract the land use data of the studied region in 1992, 2001 and 2010 respectively, so as to obtain the basic data of land use change in Zhaozhou County during 1992-2010. Thus the author could calculate the dynamic transfer matrix of the land use type, the dynamic degree index of land use and undertake quantitative analysis of the land use changes in this region. The results indicated that the forestland area of Zhaozhou County has been increasing rapidly, with the increasing investments in local agricultural and husbandry industry as well as the continuous development of cultivation industry, the grassland area has also been increasing massively, meanwhile, under the influence of country economic development, the area of construction land reflects the trend of fast growth, and the speed of development and use of other lands is also relatively high. From of perspective of regional LUCC spatial dynamic degree, the change of land use in Zhaozhou County is gradually transforming from the basically equilibrium state of bilateral transfer to the disequilibrium state of unilateral transfer.

Keywords: *Land Use, Dynamic Degree, Remote Sensing, Zhaozhou County*

1. Introduction

Since 1990s, Land Use/Cover Change (LUCC) has been an important part of global environmental change and an important reason to cause global environmental change, and has been increasingly and widely regarded by the international organizations and different countries, so far as concerned, it has become a frontier and hot spot in international studies on global change. In recent years, both the scope and depth of the domestic and foreign studies on regional land use change had great enhancement [1], with the economic development and surging population, urban land uses have been changing swiftly, there are relatively many studies on the urban land use changes in some metropolitan areas and economically developed regions [2], while the studies on the land use changes in medium-sized or small cities were relatively few.

This thesis, based on the survey data of land resource remote sensing, uses the methods of remote sensing and geographic information system, integrating statistics analysis, reveals the characteristics of the quantitative changes and spatial changes of land use in

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Zhaozhou County during 1992-2000, clears the main types and regional differences of such changes, sets foundation for the land management decision-making and biological environment protection of this region and further studies, therefore, it has great significance for the sustainable use of lands in the region.

2. Profile of the Studied Region

Zhaozhou County is under Daqing City of Heilongjiang Province, located in the southwest part of Heilongjiang Province, north of Songhua River and inland of Songneng Plain. The region has Daqing Oil Field on its back, neighbors Zhaodong City in the east, borders with Datong District in the west, borders with Zhaoyuan County in the south, and connects with Anda City in the north; this county is an important county on the golden economic belt composed of Changchun, Harbin and Tsitsihar. The county's geographic coordinates are 124°48′12″—125°48′03″ east longitude and 45°35′02″—46°16′08″ northern latitude. The entire territory of the county is 77km on south-north direction and 72km on east-west direction, the county occupies 2,398km2 of land, governing 6 towns, 6 townships, 2 farms, 104 administrative villages and 731 natural villages. Zhaozhou County is located at the first accumulated temperature zone of Heilongjiang Province, having mid-temperature continental monsoon climate, annual average active accumulated temperature of 2800℃, frost-free season of 143 days. The entire territory is in flood plains with flat terrain and average elevation of 150m.

3. Data Source and Study Method

3.1. Data Source

The remote sensing image data of the studied area includes the landsat TM multi-channel data during the three stages of 1992, 2001 and 2010; the other topographic maps are the national 1:50,000 topographic maps.

3.2. Study Method

By using the remote sensing image processing ENVI software, the author firstly undertook geometric correction, inset, geometric registration, supervised classification on the remote sensing images of the 3 time phases, so as to extract the main land use types and extract the information of land use changes, based on which the author established the dynamic transfer matrix of land use changes and the spatial distribution map of main change types. Under the support of ArcGIS, EXCEL and other software, the author calculated the dynamic transfer matrix of land use of Zhaozhou County, the dynamic degree of land use and other models, so as to undertake quantitative analysis on the temporary and spatial changes of land use of the region during 1992-2010.

4. Extraction of Remote Sensing Image Information

The preprocessing of remote sensing images includes wave band processing, geometric correction, matching and cutting of images. After using ENVI software for computer supervised classification and processing of remote sensing images, the author used the ArcMap mapping function to receive the present land use map of the studied region in 1992, 2001 and 2010 respectively (Figure 1, Figure 2 and Figure 3) as well as the dynamic change map of land use during 1992-2001 and 2001-2010 respectively (Figure 4 and Figure 5).

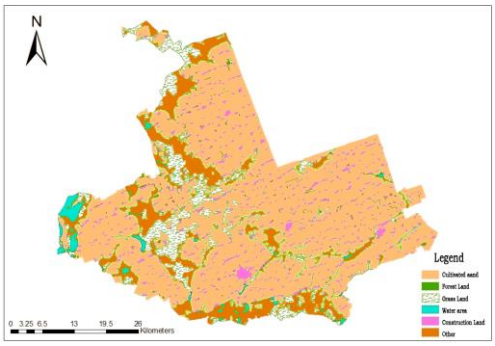

Figure 1. Present Land Use Map of Zhaozhou in 1992

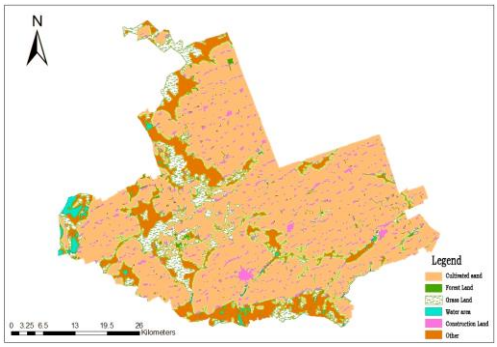

Figure 2. Present Land Use Map of Zhaozhou in 2001

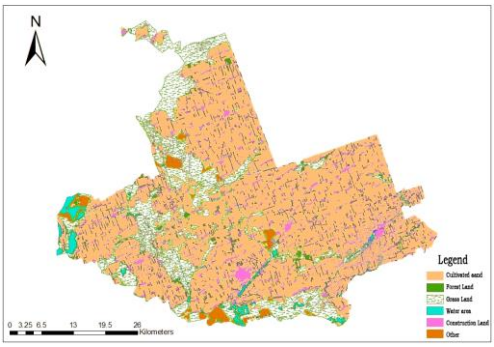

Figure 3. Present Land Use Map of Zhaozhou in 2010

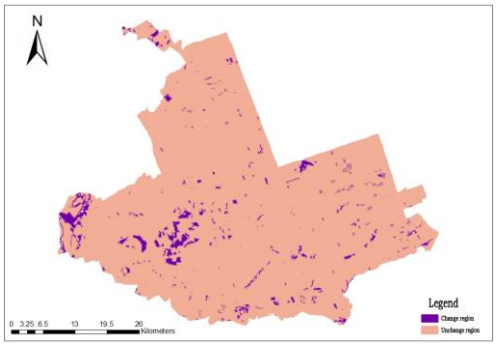

Figure 4. Dynamic Change and Spatial Distribution Map of Land Use in Zhaozhou during 1992-2001

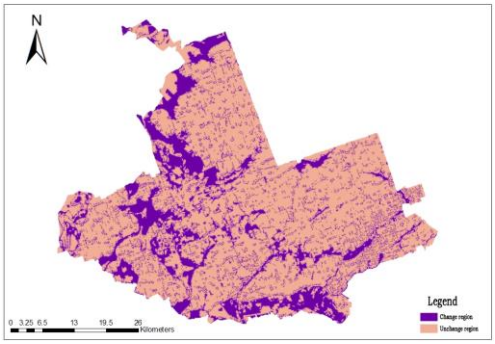

Figure 5. Dynamic Change and Spatial Distribution Map of Land Use in Zhaozhou County during 2001-2010

5. Result Analysis

5.1. Dynamic Transfer Matrix of Land Use

In order to analyze the transfer tendency of land use type, the classification result of different remote sensing images were calculated in the ArcGIS and Excel software, thus the variation between different land use types of the studied region during 1992-2001 and 2001-2010 could be obtained. By combining the same land type code of the cultivated land, forest land, grassland, water area, construction land and other land types of the vector data during the three phases of 1992, 2001 and 2010 into the same land type through the combining tool of ArcGIS, we could obtain the related new data table for the six types of land; by interactive operation for the vector data of each two of the three phases, we could obtain the land type code conversion table of each land type, and we could calculate the total area of the land types that have change of area in ArcGIS; the author then exported the data into document in dbf format, and used the tools of PivotTable and PivotChart in Excel to undertake the calculation and operation on the related data for each two of the data; then had the change transfer matrix of land use in Zhaozhou County[3] (Table 1 and Table 2).

Table 1. Conversion Matrix of Land Use in the Study Area of Zhaozhou from 1992 to 2001 Unit: hm2

Type	Cultivated land	Forest land	Grassland	Water area	Construction land	Other	Total
Cultivated land	159705.69	316.33	991.05	37.10	287.05	257.61	161594.84
Forest land	191.67	1324.92	10.76	0	5.97	9.04	1542.37
Grassland	1911.88	266.76	17726.66	177.63	4.53	686.18	20773.64
Water area	16.93	0	584.14	2625.69	0.01	1465.95	4692.72
Construction land	190.37	5.24	0.18	0	13406.86	0.37	13603.02
Other	79.06	14.03	1040.11	417.02	9.49	36049.85	37609.56
Total	162095.6	1927.29	20352.9	3257.45	13713.91	38469	239816.15

Table 2. Conversion Matrix of Land Use in the Study Area of Zhaozhou from 2001 to 2010 Unit: hm2

Type	Cultivated land	Forest land	Grassland	Water area	Construction land	Other	Total
Cultivated land	147935.67	4698.22	2448.38	390.39	5739.37	386.23	162095.6
Forest land	965.43	759.94	66.55	7.46	172.27	3.79	1927.29
Grassland	4075.31	599.01	13116.29	641.44	713.98	1394.83	20352.9
Water area	55.48	17.16	577.19	2482.84	45.30	132.49	3257.45
Construction land	2925.26	581.06	462.39	49.64	9715.84	84.03	13713.91
Other	2650.06	646.34	27777.47	1872.82	1516.30	4109.97	38469
Total	158607.21	7301.74	44448.27	5444.58	17903.07	6111.34	239816.15

It can be generally seen from the afore-mentioned two tables that the change of land use during 1992-2001 and 2001-2010 were mainly from cultivated land to forest land, grassland and construction land; the forest lands were mainly transformed into cultivated lands and construction lands; the grasslands were mainly transformed into cultivated lands, forest lands and other lands; the water areas were mainly transformed into grasslands and other lands; the construction lands were mainly transformed into cultivated lands, forest lands and grasslands; the other lands were mainly transformed into cultivated lands, grasslands, water areas and construction lands.

5.1.1. Analysis On Cultivated Land Transformation: During the period from 1992 to 2001, the transformation of cultivated lands to other types of land was mainly reflected as the transformation to forest lands, grasslands and construction lands, and the quantities of transformation were 316.33hm^2, 991.05hm^2 and 287.05hm^2 respectively, accounting for 16.74%, 52.46% and 15.19% respectively in the total quantity of the cultivated lands transformed into other types of land. Among the other types of lands transformed into cultivated lands, forest lands accounted for 8.02%, grasslands accounted for 80% and the construction lands accounted for 7.97%, but the total quantity of cultivated lands had net increase by 500.75hm^2. During the period from 2001 to 2010, the cultivated lands were transformed mainly into forest lands, grasslands and construction lands, and their quantities of transformation were 4,698.22hm^2, 2,448.38hm^2 and 5,739.37hm^2 respectively, which were much higher than the quantities of transformation in previous period. Among the other types of lands transformed into cultivated lands, grasslands accounted for 38.19%, construction lands accounted for 27.41% and the other lands accounted for 24.83%, compared with the previous period, the transforming ratio of grasslands decreased, but the quantity of transformation of construction lands increased, meanwhile, there were transformations of other lands, however, in general, the total quantity of cultivated lands decreased during the period with a net decrease of 2,991.05hm^2.

5.1.2. Analysis On Forest Land Transformation: During the period from 1992 to 2001, the forest lands were transformed mainly into cultivated lands, grasslands and other lands, the areas of transformed lands were 1,91.67hm^2, 10.76hm^2 and 9.04hm^2 respectively, accounting for 88.15%, 4.95% and 4.16% respectively of the total quantity of lands transformed into other types. The other types of lands that were transformed into forest

lands were mainly forest lands and grass lands, accounting for 52.51% and 44.29% respectively of the total quantity of transformation. During the period, the total quantity of forest lands had an increase of 384.92hm^2 in total. During the period from 2001-2010, the forest lands mainly reflected the trend of transformation into cultivated lands and construction lands. The areas of forest lands transformed into cultivated lands and construction lands were 965.43hm^2 and 172.27hm^2 respectively. The other types of lands transformed into forest lands were mainly cultivated lands, grasslands, construction lands and other lands, accounting for 71.82%, 9.16%, 8.88% and 9.88% of the total quantity respectively. During the period, the total quantity of forest lands still had continuous growth with a net increase of 5,326.30hm^2 on the basis of the number in previous period.

5.1.3. Analysis On Grassland Transformation: During the period from 1992 to 2001, grasslands were transformed mainly into cultivated lands, forest lands, water areas and other lands, the areas of transformation were 1,911.88hm^2, 266.76hm^2, 177.63hm^2 and 686.18hm^2 respectively, accounting for 62.75%, 8.76%, 5.83% and 22.52% respectively of the total quantity of grasslands transformed into other types. Meanwhile, the other types of land transformed into grasslands were mainly cultivated lands, water areas and other lands with areas of transformation of 991.05hm^2, 584.14hm^2 and 1040.11hm^2 respectively, accounting for 37.74%, 22.24% and 39.6% respectively of the total quantity. During the period, the total quantity of grasslands had a decrease of 420.74hm^2 in total. During the period from 2001 to 2010, 4,075.31hm^2 of grasslands were transformed into cultivated lands, accounting form 54.89% of the total quantity of transformation, 713.98hm^2 was transformed into construction lands, accounting for 9.62% of the total quantity of transformation, 1,394.83hm^2 was transformed into other lands, accounting for 18.79% of the total quantity of transformation. Meanwhile, the cultivated lands and other lands were mainly used to make up for the loss of grasslands, accounting for 7.81% and 88.66% of the total quantity of transformation respectively, during the period, the total quantity of grasslands had extensive growth with net increase of 23,907.41hm^2.

5.1.4. Analysis on Water Area Transformation: Zhaozhou County has relatively abundant water area resources, mainly including rivers, lake surfaces, reservoirs and ponds. During the period from 1992 to 2001, 584.14hm^2 of water areas were transformed into grasslands and 1,465.95hm^2 was transformed into other lands, accounting for 28.26% and 70.92% respectively in the total quantity of transformation. Meanwhile, there other types of land transformed into water areas were mainly grasslands and other lands with areas of transformation of 177.63hm^2 and 417.02hm^2 respectively, accounting for 28.12% and 66.01% respectively of the total number of transformation, generally speaking, the total quantity of water areas in this period decreased by 1,435.27hm^2. During the period from 2001 to 2010, water areas were transformed mainly into grasslands and construction lands with transformation quantity of 577.19hm^2 and 132.49hm^2 respectively, accounting for 69.74% and 16.01% respectively in the total quantity of transformation. The other types of lands transformed into water areas were mainly cultivated lands, grasslands and other lands, accounting for 13.18%, 21.66% and 63.23% respectively in the total quantity of transformation, water areas in this period generally reflected the trend of increase and increased by 2,134.12hm^2 in area.

5.1.5. Analysis On Construction Land Transformation: During the period from 1992 to 2001, the transformation of construction lands into other types of lands was mainly reflected as the transformation into cultivated lands, the quantity of such transformation was 190.37hm^2, accounting for 97.04% of the total quantity of transformation. Meanwhile, the other types of lands transformed into construction lands were also mainly cultivated lands and few other lands, the quantities of which were 287.05hm^2 and 9.49hm^2 respectively, accounting for 93.49% and 3.09% of the total quantity of transformation

respectively, it can be seen that the transformation between construction lands and cultivated lands was relatively frequent during the period, and the quantity of transformation was also relatively high, but generally speaking, the area of construction lands also increased by 110.89hm^2 in total. During the period from 2001 to 2010, the other types of lands transformed into construction lands were cultivated lands, forest lands and grasslands in the sequence of quantity, which were 2925.26hm^2, 581.06hm^2 and 462.39hm^2 respectively, accounting for 71.31%, 14.16% and 11.27% respectively in the total quantity of construction lands transformed into other types. Meanwhile, it can be seen that the loss of construction lands was made up mainly by cultivated lands, grasslands and other lands, which accounted for 70.10%, 8.72% and 18.52% of the total quantity of transformation respectively. It can be seen that the rapid increase of construction lands was realized mainly relying on the occupation of large amount of cultivated lands, then forest lands and grasslands. Compared with the quantity during 1992-2001, the construction lands still had continuous increase, but the extent of growth was relatively high, its area increased by 4,084.85hm^2, which was much higher than 110.89hm^2 in the previous period.

5.1.6. Analysis on Other Land Transformation: During the period from 1992 to 2001, 79.06hm^2 of other lands were transformed into cultivated lands, 1,040.11hm^2 was transformed into grasslands, and 417.02hm 2 was transformed into water areas, accounting for 5.07%, 66.69% and 26.74% of the total quantity of transformation respectively. Meanwhile, other lands were mainly transformed from cultivated lands, grasslands and water areas, the areas of transformation were 257.61hm^2, 686.18hm^2 and 1,465.95hm^2 respectively, accounting for 10.65%, 28.36% and 60.60% of the total quantity of transformation. During the period, the other lands had net increase of 859.44hm^2. During the period from 2001 to 2010, the other lands were mainly transformed into cultivated lands, forest lands, grasslands, water areas and construction lands, the quantities of transformation were 2,650.06hm^2, 646.34hm^2, 27,777.47hm^2, 1,872.82hm^2 and 1,516.30hm^2 respectively, accounting for 7.69%, 1.88%, 80.60%, 5.43% and 4.40% of the total quantity of transformation respectively, meanwhile, the other lands were mainly transformed from cultivated lands, grasslands and water areas, accounting for 19.30%, 69.69% and 4.20% of the total quantity of transformation respectively, but the total quantity of other lands had radical decrease with net decrease of 32,461.61hm^2, it can be seen that the other lands were fully utilized during this period.

5.2. Dynamic Degree of Land Use

5.2.1. Dynamic Degree Of The Change Of Single Or Comprehensive Land Use: Using the dynamic degree model of land use to quantitatively reflect the velocity of land use changes in the region, comparing the difference of land use changes in different periods and estimating the tendency of land use changes in the future have active significance. The dynamic degree of single land use type means the quantity change of certain land use type in certain studied region during certain period. Its calculation formula is [4]:

$$Rs = (Ub - Ua)/Ua \times (1/T) \times 100\% \quad (1)$$

In the formula; Ua and Ub respectively represent the quantity of certain land use type at the beginning and end of the studying period; T represents the length of studying period; K represents the dynamic degree of certain land use type during the studying period. When setting T as year, K represents the annual changing rate of certain land use type of the studied region.

The calculation formula of the dynamic degree of the comprehensive land use of

certain studied region is [5]:

$$R_t = \frac{\sum_{i=1}^{n} \left| \Delta U_{in\text{-}i} - \Delta U_{out-in} \right|}{2\sum_{i=1}^{n} U_{ai}} \times \frac{1}{T} \times 100\% \quad (2)$$

In the formula: ΔUin−I represents the sum of the areas of other types transformed into type i during the studying period; ΔUout−I represents the sum of the areas of other types that type i was transformed into; $\sum_{i=1}^{n} U_{ai}$ represents the sum of the areas of various land use types at the beginning of the studying period; Rt value represents the annual comprehensive changing rate of land use in the studied region. Through calculation, we could obtain the dynamic changing degree of single land use [6] and the dynamic degree of comprehensive land use [7] of Zhaozhou County from 2001 to 2010; the results are as follows in Table 5.

Table 3. Dynamic Degree of Land Use Change in the Study Area of Zhaozhou from 1992 to 2010 (%)

	Studied type	Changing rate in the first 9 years	Changing rate in the second 9 years	Annual changing rate during 18 years
Single dynamic degree	Cultivated lands	0.03	-0.21	-0.21
	Forest lands	2.77	29.96	41.49
	Grasslands	-0.23	12.93	12.66
	Water areas	-3.40	7.16	1.78
	Construction lands	0.09	3.28	3.51
	Others	0.25	-9.35	-9.31
Regional comprehensive dynamic degree		0.09	1.64	0.86

It can be seen from the table above that among the 6 land use types, forest lands had the highest annual changing rate, and grasslands came second, then other lands and construction lands. It proved that the area of forest lands has been rapidly growing due to the high regards of the biological environment construction by Zhaozhou County during the recent 18 years, with the enlargement of investments in local agricultural and husbandry industries, the area of grasslands has also been growing rapidly, under the influence of county economic development, the area of construction lands reflected the tendency of rapid growth, and the velocity of the development and use of other lands was relatively fast. The data above also reflected that during the period from 1992 to 2010, the annual average changing rate of the comprehensive land use in the studied region was 0.86%, in which the annual average changing rate of comprehensive land use in the second 9 years was faster than that of the first 9 years, and 18 times faster, which means that the studied region had great adjustment and change in terms of land use during the period from 2001 to 2010.

5.2.2. Spatial Dynamic Degree Of Land Use Changes: In order to have deeper analysis on the various land use data types of the studied region, after analyzing the quantity changes and the transfer matrix and the single and comprehensive dynamic degree of the quantity changes between different land types, the author comprehensively used the data to undertake the related research and analysis on the spatial dynamic degree of land use changes and the tendency status index, for the transfer index model between the used land

types[8], please refer to Table 6. In the table, U_a represents the quantity of certain land use type at the beginning of studying period; ΔU_{in} represents the sum of the area of other types transformed into such type during the studying period T, ΔU_{out} represents the sum of the areas of certain type transformed into other types; ΔU_{in-i} represents the sum of the areas of other types transformed into type i during the studying period; ΔU_{out-i} represents the sum of the areas of type i transformed into other types; $\sum_{i=1}^{n} U_{ai}$ represents the sum of the areas of various land use types at the beginning of the studying period.

Table 4. The Change of Land Use Type Transfer Index Model

Name and symbol of the selected index model	Expression
Spatial dynamic degree of single land use changes (R_{ss})	$R_{ss} = \frac{\Delta U_{in} - \Delta U_{out}}{U_a} \times \frac{1}{T} \times 100\%$
Tendency status index of single land use changes (P_s)	$P_s = \frac{R_s}{R_{ss}} = \frac{\Delta U_{in} - \Delta U_{out}}{\Delta U_{in} + \Delta U_{out}}, \left\lvert \frac{R_s}{R_{ss}} \right\rvert \le 1,$ or $-1 \le P_s \le 1$
Spatial dynamic change of regional land use changes (R_{ts})	$R_{ts} = \frac{\sum_{i=1}^{n} (\Delta U_{in-i} + \Delta U_{out-i})}{2\sum_{i=1}^{n} U_{ai}} \times \frac{1}{T} \times 100\%$
Tendency status index of regional land use changes (P_t)	$P_t = \frac{\sum_{i=1}^{n} \lvert \Delta U_{in} - \Delta U_{out} \rvert}{\sum_{i=1}^{n} \lvert \Delta U_{in} + \Delta U_{out} \rvert}, 0 \le \frac{R_t}{R_{ts}} \le 1,$ or $0 \le P_t \le 1$

Based on the transfer matrix data during 1992-2001 and 2001-2010, the statistics and calculation could be made respectively about the spatial dynamic degree and tendency status index[9] of the single and regional comprehensive land use changes during the two periods of 1992-2001 and 2001-2010, the results are as follows in Table 7.

Table 5. The Change Of Land Use Spatial Dynamic Degree In The Study Area of Zhaozhou from 2001 to 2010 and from 2001 to 2010 (%)

	1992-2001		2001-2010	
	Spatial dynamic degree (Single R_{ss}, Comprehensive R_{ts})	Tendency status index (Single P_s, Comprehensive P_t)	Spatial dynamic degree (Single R_{ss}, Comprehensive R_{ts})	Tendency status index (Single P_s, Comprehensive P_t)
Cultivated lands	0.294	0.117	1.673	-0.123
Forest lands	5.906	0.470	43.632	0.687
Grasslands	3.034	-0.074	20.964	0.617
Water areas	6.390	-0.532	12.718	0.563
Construction lands	0.411	0.220	9.882	0.332

Others	1.175	0.216	10.504	-0.890
Comprehensive in the region	0.416	0.207	2.858	0.575

It can be seen from the analysis of the data in the table (row of R_{ss}) that the change of water areas during 1992-2001 had the highest spatial dynamic degree, forest lands and grasslands came second, which means that the in-out transformations of the land use types of water areas and forest lands during the studying period were frequent, or the percentage of transformation quantities in their areas at beginning of periods was relatively high. From 2001 to 2010, the change of forest lands had the highest spatial dynamic degree, grasslands and water areas came second, then other lands and construction lands, which both had extensive growth compared with the overall spatial dynamic degree value in previous period, which means, during this period, besides the foresaid types of land se had relatively high in-out transformation frequency or relatively high percentage of transformation quantity in their respective areas at the beginning of period, the ratio of transformation areas between different land types also had changes in relatively bigger scale. The ones with the lowest spatial dynamic degrees during the two periods were both cultivated lands, which mean that the spatial transfer of cultivated lands from 1992 to 2010 wasn't frequent, or the percentage of transformation quantity in the area at the beginning of period was not high.

Analyzing from the P_s row, when $0 \leq P_s \leq 1$, the land use type developed towards the direction of increased scale, such type was in "increasing" status. The more P_s approached 0, which means the scale growth of such land use type was slower, and the bilateral transformations were more frequent, reflecting the equilibrium state, but the areas of transformation into other types were slightly lower than the areas of other types transformed into this type, such as the cultivated lands from 1992 to 2001 and the construction lands from 2001 to 2010; the more the P_s approached 1, which means the transformation direction of land use types was mainly the transformation of other types into this type, reflecting an extremely un equilibrium state, and causing the areas of such type to be increased steadily, such as the forest lands during the two periods.

When $-1 \leq P_s \leq 0$, which means the land use type developed towards the direction of decreased scale, then such type was in "decreasing" status. As P_s approaches 0, which means the scale decrease of such type was slower and the bilateral transformations were more frequent, reflecting the equilibrium state, but the areas of the transformation into other types were slightly higher than the areas of other types transformed into this type, such as the grasslands from 1992 to 2001 and the cultivated lands from 2001 to 2010; as P_s approaches -1, which means the transformation direction of land use type was mainly the transformation of this type into other types, reflecting an extremely un equilibrium state, causing this type to be gradually shrinking in scale, such as the water areas from 1992 to 2001 and the other lands from 2001 to 2010.

From the perspective of regional LUCC spatial dynamic degree (R_{ts}), the total spatial transformation quantity (transformation in or out) of various land use types of Zhaozhou County from 2001 to 2010 increased compared with that of previous period. Analyzing from the regional spatial change tendency status index (P_t), as P_t approaches 0, which means the bilateral transformation of all land use types in the region were more frequent, and reflected the tendency of balanced transformation; as it approaches 1, which means the transformation direction of each land use type was mainly the unilateral transfer of extreme imbalance, or the transformation of this type into other types, or the transformation of other types into this type. For the purpose of better expressing and understanding the trend and status of LUCC, the overall tendency and status index of regional LUC could be classified: when $0 \leq P_t \leq 0.25$, the regional LUC is defined to be in equilibrium state; when $0.25 \leq P_t \leq 0.50$, the regional LUCC is defined to be in

quasi-equilibrium state; when $0.50 \leq P_t \leq 0.75$, the regional LUCC is defined to be in unbalanced state; when $0.75 \leq P_t \leq 1$, the regional LUCC is defined to be in extremely unbalanced state. It can be seen from the data in Table 5 that the change of land use in Zhaozhou County gradually transformed from basically the equilibrium state in bilateral transformation into the unilaterally unbalanced state transformation.

6. Conclusion and Discussion

(1) The quantity changes of land use in the studied region have obvious variety, the total quantity of grasslands during the studying period increased by 23,674.51hm^2, while the areas of other lands decreased by 31,498.27hm^2, the two were the land types with the most obvious area changes.

(2) The area of forest lands of Zhaozhou County has been growing rapidly in the recent 18 years, with the enlargement of investments in local agricultural and husbandry industries and the continuous development of cultivation industry, the area of grasslands has also been growing rapidly, meanwhile, under the influence of county economic development, the area of construction lands reflected the tendency of rapid growth, and the velocity of the development and use of other lands was relatively fast. Besides, comparing with the period from 1992 to 2001, Zhaozhou County had great adjustments and changes in terms of the quantity of land use types from 2001 to 2010.

(3) From 1992 to 2001, Zhaozhou County had relatively big adjustment in the distribution and use of water areas and forest lands, comparing with the period from 2001 to 2010, besides forest lands and water areas, Zhaozhou County had relatively big adjustments and changes on the use of grasslands, construction lands and other lands, therefore, the spatial dynamic degree index of the foresaid land types had obvious changes. Comparing with the afore-mentioned land types, Zhaozhou County had good control on the maintaining quantity and transformation of the cultivated lands during the last 18 years, the area of cultivated lands had basically no extensive changes.

(4) From the perspective of tendency status index, the scale growth of the cultivated lands from 1992 to 2001 and the construction lands from 2001 to 2010 was relatively slow, and the bilateral transformations were relatively frequent, reflecting the equilibrium state, but the areas of transformation into other types were relatively lower than the areas of other types transformed into this type; the growth of forest lands during the two periods reflected extremely unbalanced state, causing the area of such type to be growing steadily. The decrease of grasslands from 1992 to 2001 and the decrease of cultivated lands from 2001 to 2010 were relatively slow, and the bilateral transformation was frequent, reflecting the equilibrium state, but the areas of this type transformed into other types were slightly higher than the areas of other types transformed into this type; the scale of water areas from 1992 to 2001 and the scale of other lands from 2001 to 2010 shrunk gradually and reflected the extremely unbalanced state.

(5) From the perspective of regional LUCC spatial dynamic degree, the land use changes of Zhaozhou County gradually transformed from basically equilibrium state of bilateral transformation into the unbalanced state of unilateral transformation.

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