Spatial-temporal Pattern Evolution of Ecological Land Use in Hebei Province

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Abstract. Ecological land use is an important component of ecosystem. This study presents spatial and temporal pattern evolution characteristics of ecological land for the period from 2009 to 2017, based on GIS technology and mathematical statistics. The results show that ecological land structure is stable, amount tends to decrease, average annual decrease of 21,000 hm². Ecological land types were mainly transformed into farmland and urban land, Internal transformed mainly between woodland and grassland. Spatial aggregation were existed, Aggregation degree: forest land > grassland > water area and wetland > desert. But high concentration areas ("HH" related area) is reduced from 11 counties to 9 counties, and low concentration areas ("LL" related areas) increased from 37 counties to 40 counties, from 2009 to 2017. According to the results, proposals for ecological land use were put forward.

1 Introduction

Ecological land use important research subject in global environmental change and sustainable development. because it could promote the sustainable use of uatural resources. Bailey [1] put forward the concept of composite ecosystem. Zonneveld [2] analyse ecological land by grade distribution theory. Ecological land use is also an important component of the European land use classification system [3] and in United States land use planning [4]. The research contents of scholars are mainly concentrated on the definition, spatial and temporal pattern evolution and driving force. Dong Yawen [5] described the ecological land from patch and corridor forms in the study of ecological protection in urbanized areas. Yuejian [6] described ecological land qualitatively, could classify the status of land as "unused". On the basis of the classification, scholars have explored the temporal and spatial patterns and driving forces at the national level, key areas or specific areas. Some scholars have also measured and analysed the value of ecological services. The research methods mainly include geographic detector analysis, transfer matrix, regression model, and so on.

In the paper, analyses changes of structure, quantity and type variations, then presents spatial and temporal pattern evolution characteristics of ecological land, based on GIS technology and mathematical statistics, from 2009 to 2017

2 Data sources and methods

2.1 Study area

Hebei Province, across 36° 03'N to 42° 40'N and 113° 27'E to 119° 50'E, has the total area of 188.8 × 10⁴km. Bordering the Bohai Sea in the east, Beijing and Tianjin in the inner ring, Taihang Mountain in the west, Yanshan in the north, and Zhangbei Plateau in the north of Yanshan. In the geomorphological pattern, from northwest to southeast, plateau, mountain and plain are arranged in turn, with obvious zonal distribution characteristics. There are four main river systems in the province: Haihe River System, Luanhe River System, Inland River System and Liaohe River System. With the coordinated development Hebei Province has become more and more important as the ecological environment supporting area for Beijing-Tianjin-Hebei Urban Agglomeratio.

2.2 Data sources

There is no unified standard for the classification of ecological land. Different scholars have different classification methods of ecological land types, according to the characteristics of research objects, characteristics and purposes. In this paper uses the results of the Key Laboratory of Land Use of the Ministry of Natural Resources. Because the results have realized the connection between ecological land use and national standards, and have the characteristics of simple operation and strong practicability. (table 1). The data of land use change survey from 2009 to 2017.

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Table. 1. Classification of ecological land use types and comparison table with land use status classification

Ecological Land Classification	Classification of land use status
Woodland	Woodlands, Shrubs and Other woodlands.
Grassland	Natural grassland, Artificial grassland and Other grasslands
Meadow	Natural grassland. Artificial pasture
Other grasslands	Other grasslands
Waters and Wetlands	Rivers, Lakes, Reservoirs, Ponds, Coastal beaches, Inland beaches, Glaciers and permanent snow cover, Swamps
Desert	Sandy, Bare land

2.3 Main methods

ESDA includes global spatial autocorrelation and local spatial autocorrelation. Global spatial autocorrelation can determine whether a phenomenon or attribute value has aggregation characteristics in space. By estimating global spatial autocorrelation statistics such as Moran's I, Global Geary's and Join Count, the spatial correlation degree and spatial difference degree of regional population are analysed. The most commonly used index is Moran's I. The calculation formula is as follows:

$$I(d) = \frac{\sum_{i=1}^n \sum_{j=1}^n W_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_{i=1}^n \sum_{j=1}^n W_{ij}} \quad (1)$$

In the formula, n is the number of subjects, $\bar{X}$ the observed value and the average value of x_i . To study the spatial connection matrix between i and j , the spatial connection matrix represents the potential forces of interaction between spatial elements. Spatial connection matrix is generally expressed as N -dimensional matrix W ($n \times n$), which is determined by spatial adjacency and spatial distance. Moran's I value is between -1 and 1, $I > 0$ indicates spatial autocorrelation, spatial entity is aggregated distribution, $I < 0$ indicates spatial negative correlation, spatial entity is discrete distribution, $I = 0$ means spatial entity is random distribution. The larger the I value, the greater the correlation of spatial distribution. Local spatial autocorrelation can measure the spatial location and range of spatial heterogeneous aggregates of phenomena or attribute values. Local Moran's I statistics and LISA indicators are used to reveal the degree of spatial autocorrelation of each regional unit. LISA essentially decomposes Global Moran's I into regional units.

3 Research results and analysis

3.1 Flow direction analysis of ecological land

The total amount of ecological land in Hebei Province decreased from 8.88×10^6 hm^2 to 8.71×10^6 hm^2 during the research period, average annual decrease of 2.1×10^4 hm^2 . The largest reduction of land types was grassland, reduced area was 6.2×10^4 hm^2 . Secondly, the decrease of water-wetland was 4.2×10^4 hm^2 . On the whole, the annual change of ecological land tends to decrease, decreased change rate from 0.2% to 0.3%. The forestland decreased from 0.05% to 0.16%, the water - wetland decreased from 0.4% to 1.34%. The proportion of forest land: grassland: water-wetland: desert were 0.5:0.3:0.1:0.1.

Fig. 1. Change Range of Ecological Land in Hebei Province from 2010 to 2017

There is a case of ecological land changed to other land types. From the perspective of variation, the first is ecological land changed to cultivated land about 9.6×10^4 hm^2 . Secondly, changed to urban land was 5.0×10^4 hm^2 , cultivated land and urban land accounted for 85.9% of the total ecological land changed.

Internal transformation of ecological land, it mainly occurs between forestland and grassland. The forestland changed to grassland was 3213 hm^2 , followed forestland changed to water-wetland was 770.63 hm^2 . The total other land types changed to forestland was 3691.00 hm^2 . The main source from cultivated land, accounted for 69.50%. The forestland changed to other land types, was urban land, accounted for 42.69%.

The grassland mainly come from woodland, accounted for 47.57%. The grassland mainly changed to cultivated land, accounted for 62.34%. The ecological land transferred from water-wetland was 6155.72 hm^2 . Forestland and water conservancy facility land, changed to grassland were 770.63 hm^2 and 608.46 hm^2 respectively. The water-wetland total area changed to other land types was 4.9×10^4 hm^2 . The water-wetland mainly changed to arable land, accounted for 49.94% of the total water - wetland.

3.2 Spatial evolution analysis

3.2.1 Global spatial autocorrelation analysis of ecological land use in Hebei Province

GeoDa software was used to calculate the Moran's I index of ecological land and various types of land. The results showed that the Moran's I index of ecological land, woodland and grassland were tested by Monte

Carlo simulation method. Moran's I index were 0.7450, 0.744\0.695. The larger the index, the greater the degree of spatial aggregation. Forestland and grassland have a greater impact on spatial aggregation of ecological land. According to the survey spatial aggregation degree of forestland > grassland > water area-wetland > desert; Compared with 2009, the spatial aggregation degree of ecological land decreased in 2017.

3.2.2 Spatial autocorrelation analysis of ecological land in Hebei Province

In order to further reveal the location of agglomeration, local autocorrelation analysis was used, and the Cluster Map of ecological land in 2009 and 2017 was obtained.

Fig. 2. Change of Spatial Aggregation Patterns of Ecological Land in Hebei Province from 2010 to 2017

(1) The high concentration areas ("HH" related area) In 2009, there were 11 counties, which decreased to 9 counties in 2017. This area mainly distributes in the eastern part of Zhangjiakou and the northern part of Chengde. The Ba-shang Plateau has been an important forest area in study area. The famous Saihanba Forest Farm is also located in this area, and the ecological land in the area has maintained a high level in history. Regional differences in ecological land use, forest land accounted for about 70% of the total ecological land, in Chengde city. While in Zhangjiakou city, grassland accounted for about 40%. The highest proportion of woodland Weichang County is 77%, and that of grassland in Huailai County is 44%.

(2) Low concentration areas ("LL" related areas), in 2009, there were 37 counties in this area, with an added to 40 in 2017. Human activities are frequent in this area. Agricultural land and construction land are the priority in land use, while ecological land is less. From the point of view of geomorphology, the region is located in the central and south eastern part of the province. It is mainly composed of Piedmont plain, central plain and coastal plain. It is formed by alleviation of ancient Yellow River, Haihe River and Luanhe River. The Haihe River basin runs through the whole territory. Haihe River system collects water from Yanshan Mountain and Taihang Mountain, forming fan-like water system. The ecological land mainly consists of water area, wetland and woodland, while the grassland and desert land are less. The proportion of wetland to ecological land ranges from 0.1 to 0.9, of which 26 counties ranges 0.3 to 0.9.

Distribution characteristics are obvious according to river trend. Because most of Baiyangdian Lake in Anxin County makes the proportion of water - wetland in the county's ecological land as high as 0.8. The Luanhe River system is located in the eastern Hebei Province. After the eastern Hebei Plain, it enters the sea in Changli county and Leping county. So the proportion of these areas water-wetland in the area are higher. The proportion of forestland to ecological land in 28 counties ranges from 0.3 to 0.7. The distribution of Forestland is more dispersed. The Forestland in this area is different from the natural forestland in mountain and plateau areas such as Zhangjiakou and Chengde. Most of the forestland in this area is planted forest.

(3) HL and LH region do not exist in the spatial distribution of ecological land in Hebei Province.

4 Conclusions and suggestions

The paper systematically analysed the status of ecological land use in Hebei Province from 2009 to 2017. The results showed that: (1) The proportion of forest land, grassland, water area, wetland and desert in the total ecological land use was relatively stable at 0.5:0.3:0.1:0.1:0.1. The ecological land decreased by 2.1×10^4 hm^2 annually. The absolute value of ecological land use change decreased from 0.2% to 0.3%. (2) The conversion of ecological land to agricultural land and construction land was 9.6×10^4 hm^2 of cultivated land. The internal conversion of ecological land mainly occurred between forest land and grassland. The forest land changed to grassland was 3213 hm^2 . (3) The spatial aggregation degree of forest land > grassland > water area and wetland > desert. (4) The "HH" correlation area was reduced from 11 counties in 2009 to 9 counties, mainly distributed in the eastern part of Zhangjiakou and northern part of Chengde. The "LL" correlation area was from 37 counties added to 40. The main ecological land in this area is water area, wetland and woodland. The wetland in water area has obvious distribution characteristics according to the trend of rivers.

From the research results, it can be seen that the structure of ecological land is relatively stable and the total amount of ecological land tends to decrease. With more and more attention to ecological protection, the combination of advanced engineering technology and ecological protection will reverse the trend of ecological land reduction. In addition to focusing on quantity, we can consider breaking administrative boundaries and dividing protection units according to geographic factors. Such as topography, landform and river distribution. Based on the 9 counties in HH area, they are further divided into the grassland protection area of Bashang Plateau, the forest land protection area of central and southern Yanshan Mountains, and the forest and grassland belt of Liaohe-Luanhe River. LL areas should not only consider the actual requirements of economic development for ecological land use, but also strengthen the protection and restoration of ecological environment.

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