Temporal and Spatial Changes of Land Use in Donghe District of Baotou City and Its Impact on Ecological Environment

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Abstract: Taking Donghe District, Baotou City, Inner Mongolia Autonomous Region as an example, research on land use change and its ecological environment response was carried out to provide theoretical support for the coordinated development of regional economy and ecological environment. Based on Landsat 4, 5 TM images from 1990 to 2010 and Landsat 8 OLI satellite remote sensing images from 2013 to 2018 to obtain land use maps, the land use transfer matrix explored the changes in land use and its ecological environment response in Donghe District from 1990 to 2018. The research results show that the urban development of Donghe District is gradually expanding to the northwest and southeast, and the area of residential and commercial service land has increased significantly in these two directions; the area of unused land has gradually decreased after soil improvement; the area of arable land has decreased in general; vegetation The area of the water body has gradually increased in recent years; the area of the water body has remained balanced as a whole. The quality of the ecological environment in Donghe District has improved.

1.Introduction

Land resources are the basis for human survival and development [1-5]. Land use/cover change (LUCC) is the main cause of global climate change and is very closely related to human activities. Therefore, the study of land use or cover change is one of the most popular research contents in the world [6-7]. Land use/cover change (LUCC) can change the structure, process, and function of ecosystems, thereby affecting ecosystem services [8]. In recent years, the use of remote sensing technology to monitor and evaluate ecosystems has become an important part of the field of ecological remote sensing [9]. Therefore, we should rationally plan the types of land use, adhere to the concept of sustainable development, and plan land use rationally to ensure the sustainable development of land resources.

2.Study area

Donghe District has a long history and is located in the southeast of Baotou City, Inner Mongolia Autonomous Region, and Daqingshan District in the south, with a total area of 470 km². The total population is 551,900 (2017). The altitude is about 1065-1120 m, and the climatic conditions are very typical continental monsoon climate. There are 47 windy days on average each year.
windy days is the most from April to June, accounting for about 52% of the annual windy days. There is sufficient sunshine throughout the year, the annual average temperature is about 6.4 °C, the temperature difference between day and night fluctuates greatly, and the frost-free time is short.

3. Data and methodology

3.1. Data

The data used in this graduation project comes from the geospatial data cloud (www.gscloud.cn), using Landsat4 and 5 TM data images from 1990-2010 and Landsat8 OLI data images from 2013-2018. In the selection of bands, Landsat 4 and 5 use band 4, band 3 and band 2 for standard false color synthesis, and Landsat 8 uses band 5, band 4, and band 3. In the selection of images, most of the images choose the remote sensing images in August and September, because for crops and vegetation, the growth in August and September is obvious, which is easy for image recognition and the data quality is high. Attention should be paid to selecting images with a cloud content of less than 5%, so as to facilitate the observation, classification and extraction of the features in the image, and to ensure the accuracy of the classification, so that the data can be researched and analyzed, and conclusions can be drawn.

3.2. research method

This paper conducts a quantitative analysis from the quantitative changes and spatial distribution of various types of land use in the study area, as well as changes in the degree of land use, to reveal the characteristics of land use in the area [10-13], using the 1996-2010 Baotou City Landsat 4, 5 TM satellite remote sensing image data of Donghe District, 2013-2018 Landsat 8 OLI satellite remote sensing image data of Donghe District, Baotou City and vector files of Donghe District, mainly using RS and GIS as spatial technology means, through the original survey area The remote sensing data is subjected to preprocessing operations such as radiation calibration, atmospheric correction, optimal band selection, image cropping, etc. [14-15], using the support vector machine classification method to extract the cultivated land, vegetation, and water bodies in Donghe District, Baotou City from 1990 to 2018, Unused land, residential and commercial service area, analyze the impact of changes on land use according to different driving factors, and give relevant planning suggestions.

4. Result and analysis

4.1. Time change analysis

Time series analysis is one of the quantitative forecasting methods, mainly based on the changes of land use types in different periods, extracting the characteristics of each category of land from the remote sensing image of the study area, and the degree of land use change can quantitatively analyze the land in the study area. Use the trend of change and the degree of comprehensive level. Figure 1 shows the images after supervision and classification in Donghe District, Baotou City in 1990, 1998, 2006, 2013, 2016, and 2018. The yellow area in the classification map represents unused land, the red area represents residential and commercial service land, the green area represents vegetation, and the blue area represents water bodies. Dark green represents cultivated land.
Figure 1 Supervised and classified images of Donghe District, Baotou City

Notes: Rcs. Residential and commercial services; Unu. Unused land; Veg. Vegetation; Ara. Arable land;

4.1.1. Area statistics

| Year | Rcs (Km²) | Unu (Km²) | Veg (Km²) | Ara (Km²) | Water (Km²) |
|------|-----------|-----------|-----------|-----------|-------------|
| 1990 | 17.84     | 45.24     | 3.33      | 7.94      | 2.12        |
| 1994 | 26.68     | 40.11     | 4.1       | 3.39      | 2.19        |
| 2002 | 30.74     | 34.86     | 7.36      | 1.42      | 2.04        |
| 2006 | 34.07     | 27.57     | 7.56      | 4.89      | 2.3         |
| 2010 | 36.77     | 28.95     | 2.73      | 5.77      | 2.24        |
| 2016 | 35.76     | 24.77     | 4.61      | 9.07      | 2.24        |
| 2018 | 40.5      | 22.01     | 8.9       | 2.74      | 2.22        |

4.1.2. Analysis of Land Use Change Trend

According to the area statistics, it can be clearly seen that the area of vegetation increased from 3.33 km² to 7.56 km² between 1990 and 2006, showing a gradual upward trend. The vegetation area in 2006-2018 increased from 2.73 km² to 8.9 km², the trend is the same as the trend in 1990-2006, and
there is a gradual increase trend; the change of the water body is not very obvious, but in 2006 the water body area reached the largest area in the past. There is 2.3 km². In 2006, vegetation and water bodies showed different laws. Therefore, this study divided the 1990-2018 period into two time periods, 1990-2006 and 2006-2018, and used the transfer matrix to study and analyze the transformation of land use.

Table 2 Land use transfer matrix from 1990 to 2006

| Type  | Water | Veg | Unu | Ara | Rcs | Total |
|-------|-------|-----|-----|-----|-----|-------|
| Water | 1.99  | 0.02| 0.28| 0   | 0.04| 2.31  |
| Veg   | 0.03  | 1.89| 2.87| 2.53| 0.22| 7.54  |
| Unu   | 0     | 0.42| 0.65| 1.73| 0.44| 4.88  |
| Ara   | 0.04  | 0.65| 2.02| 1.68| 0.44| 27.56 |
| Rcs   | 0.06  | 0.35| 14.95| 1.98| 16.7| 34.04 |
| Total | 2.12  | 3.33| 45.14| 7.92| 17.84|       |

A comparison of the area between 1990 and 2006 based on the transfer matrix data and the land use area change chart shows that the residential and commercial service area has increased from 17.84 km² to 34.07 km², and the area has increased by 16.23 km², of which unused land has been transformed into residential and commercial buildings. The area of service is 14.95 km², the area converted from cultivated land to residential and commercial service is 1.98 km², and the area converted from water and vegetation is less, 0.06 km² and 0.35 km², respectively; the area of unused land has been reduced from 45.24 km² to 25.57 km². The area was reduced by 19.67 km², most of which were converted into residential and commercial land. The areas converted into vegetation and cultivated land were 2.87 km² and 2.02 km², respectively. The area converted into water bodies was the least, with 0.28 km² converted from unused land to water body; vegetation area increased from 3.33 km² to 7.56 km², an increase of 4.23 km², of which 2.53 km² was converted into vegetation land, 0.22 km² was converted into residential and commercial service land, and 0.33 km² was converted into water body; cultivated land area was reduced from 7.94 km² to 4.89 km². The area is reduced by 3.05 km², of which 2.53 km² is converted into vegetation area, and 1.98 km² is converted into residential and commercial service land; the water area is generally balanced.

Table 3 2006-2018 Land Use Transfer Matrix

| Type | Unu | Water | Ara | Veg | Res | Total |
|------|-----|-------|-----|-----|-----|-------|
| Unu  | 15.06| 0.12  | 0.39| 2.83| 3.56| 21.96 |
| Water| 0.03 | 1.99  | 0.06| 0.07| 0.06| 2.21  |
| Ara  | 0.54 | 0     | 0.98| 0.32| 0.9 | 2.74  |
| Veg  | 5.64 | 0     | 0.45| 1.42| 1.38| 8.89  |
| Res  | 6.23 | 0.19  | 3   | 2.88| 28.14| 40.44 |
| Total| 27.5 | 2.3   | 4.88| 7.52| 34.04|       |
Figure 3 Changes in land area from 2006 to 2018

Analyzing the transition matrix in 2006 and 2018 from time changes, through the data display, we can clearly see the inflow and outflow of land use. In the land use changes in 2006 and 2018, the number of land use types and structures in Donghe District has changed significantly: unused land and cultivated land have decreased significantly, vegetation area has increased slightly, and residential and commercial service areas have increased more obviously. Among them, the area of residential and commercial services increased from 34.04 km² to 40.44 km², an increase of 6.40 km². This part of the increase was mainly due to unused land. The area converted from unused land to residential and commercial services was 3.56 km². The area of water conversion is 1.38 km², 0.9 km² and 0.06 km² respectively; the area of unused land has been reduced from 27.5 km² to 21.96 km², a decrease of 5.54 km². Most of the area is converted into residential buildings and commercial services, and a small part is converted into vegetation. The vegetation area increased from 7.52 km² to 8.89 km², an increase of 1.37 km²; the area of arable land decreased from 4.88 km² to 2.74 km²; the water body also remained basically unchanged. In general, from 2006 to 2018, the proportion of unused land converted to residential and commercial service land remained the largest. However, the overall land use change is characterized by a decline in the overall proportion of agricultural land and a significant expansion of residential and commercial service land. The water area has also been reduced.

4.2. Spatial change analysis

Spatial change analysis is a quantitative study of geospatial phenomena. The analysis of spatial change of land use is mainly based on the changes of land types, such as the direction of urban expansion, the distribution of vegetation, and the changes of administrative divisions. According to the classification maps of image supervision in 1990, 2006 and 2018, it can be seen that the residential and commercial service land in Donghe District of Baotou City has expanded significantly, gradually expanding to the northwest and southeast. The population continues to increase and the expansion of cities is an inevitable trend, and construction land should be planned reasonably on the basis of environmental protection.

This research mainly analyzes the spatial changes based on the two directions of urban expansion. The expansion in the southeast direction is based on the 110 National Highway, and the northwest direction is based on the Jiuyuan District, which is critical to the Donghe District.

(1) Analysis of spatial change with G110 national highway as the main line

G110 is a national highway. The national highway runs from Deshengmen, Beijing, through the capital Beijing, Hebei, and Inner Mongolia, to Qingtongxia in Ningxia, with a total length of 1,357 kilometers. The 110 National Highway enters in the north of Donghe District and runs through to the east of Donghe District. Because the north of G110 National Highway is a large area of unused land, this area of soil cannot be used without reasonable improvement. In this study, a 45-meter buffer zone was established with G110 as the main line in ArcGIS 10.3 software, and the changes in residential and commercial service land in the nine years from 1990 to 2018 were counted.
The above picture shows the changes in the area of residential and commercial services from 1990 to 2018. According to the data in the figure, the area of residential and commercial service land is increasing year by year to the south of the G110 National Highway. The urban construction land in Donghe District has been around the G110 National Highway. Expanding to the south, with the improvement of the facilities surrounding the 110 National Highway, the area of residential and commercial areas gradually expands in this direction, and the area continues to expand.

(2) Take the northwest direction of Donghe District and the junction of Jiuyuan District as the main line

In the northwest of Donghe District, the expansion of residential and commercial service land is obvious, and Donghe District is connected with Jiuyuan District, as shown in Figure 5. The junction of Donghe District and Jiuyuan District to the northwest is relatively close to the Baotou City Government and Jiuyuan District Government. Therefore, the development center of Donghe District has gradually moved to the northeast, with less and less unused land, residential and commercial. More and more service land is used, and the land utilization rate is gradually increasing.

5. Conclusion and discussion

(1) The urban area of Donghe District is gradually increasing. With the rapid economic and social development and continuous population growth, the area of residential and commercial service land has also gradually increased. The residential and commercial service area has increased from 17.84 km² in 1990 to 40.50 km² in 2018.

(2) The amount of water retention is basically balanced, and the total amount is basically maintained at about 2.16 km². This is mainly because the waters of the Donghe District are mainly South China Sea wetlands. It is precisely because the government’s overall planning policy protects the South China Sea wetlands. The number of possessions remains balanced on the whole.

(2) The area of unused land is gradually decreasing, and the utilization rate of land is increasing. The reduction of unused land is mainly concentrated at the junction of the mountainous area in the northeast of Donghe District and residential and commercial service land.
(4) According to the analysis of time and space changes, the urban development of Donghe District has gradually expanded to the northwest and southeast, and the area of residential and commercial service land has increased significantly in these two directions.

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