Analysis of Land Cover Change in Shenyang Based on Remote Sensing Image Supervised Classification Technology

Dayong Yang, Zhiwei Xie and Xishihui Du
Shenyang Jianzhu University, No.25, Hunnan Middle Road, Hunnan District, Shenyang, China
Email: ydy1120@163.com

Abstract. Based on four satellite remote sensing images in different periods, this paper studies the change of land cover in Shenyang urban area. For the classification of land cover, the maximum likelihood method is adopted in the experiment. The land cover change is analyzed on the classification data. The analysis showed that these changes were significant. During the period of 2000-2010, the area of construction land increased greatly, the total area of cultivated land changed little, and the area of forest land and other land decreased. With the development of the city, the proportion of all kinds of land has changed. The research results can provide some meaningful scientific help for urban planning and land use in Shenyang.

1. Introduction

In recent decades, the utilization of land resources has become a serious problem in China. With the rapid expansion of urban scale, a lot of land is occupied, which is directly related to the healthy development of the economy. At the same time, with the rapid development of remote sensing technology and GIS technology, land use/cover change research has become one of the hot spots in global change research [1].

As the economic and political center of Northeast China, the research on land cover change of Shenyang is relatively weak compared with other cities in Yangtze River Delta urban circle, Pearl River Delta urban circle and Wuhan urban circle [2]. Li and others analyzed and studied the present situation of land use in Shenyang by using the least square method based on weight [3]. Bai and others analyzed the spatial pattern of construction land in the urban-rural fringe of Shenyang by using the equal step and equal distance buffer analysis method and the equal step and equal area buffer analysis method [4]. Based on the TM remote sensing images of 2000, 2005 and 2010, Yao analyzed the temporal and spatial changes of land use and landscape pattern in Shenyang from 2000 to 2010 [5]. Xie used the method of object-oriented classification technology to analyze the dynamic changes of land use/land cover in Shenyang in 2002 and 2013 [6].

This paper uses the maximum likelihood method to classify the land cover of Shenyang city. Through the statistics of land type information, the change of land cover in Shenyang urban area from 1989 to 2016 was analyzed from the perspective of structure and dynamic attitude. This study can help decision-making departments to make more rational land use planning, which has positive practical significance for promoting rapid urban development and improving ecological environment [1, 2].
2. Research Data and Data Processing

2.1. Introduction to the Research Area
Shenyang is in the central part of Liaoning Province, with Changbai Mountain foothills. It is located in the Bohai economic circle with coordinates of 41°48′11.75″ N and 123°25′31.18″ E. The terrain of Shenyang is relatively flat, mainly plain, with an average altitude of about 50m. The terrain gradually widens to the West and south. The area has developed water system, species diversity and rich resources [7]. The study area is nine municipal districts of Shenyang City with a total area of 3423.46 square kilometers.

2.2. Data Sources
At present, scholars at home and abroad often use the images obtained by SPOT, ASTER and Landsat TM in the study of small and medium-sized land use/Cover Change [8]. Among them, the Landsat series satellite has complete historical data, wide coverage area and high ground resolution, which can be obtained free of charge, becoming the most commonly used remote sensing image in land use/Cover Change [9]. In this study, four phases of landsat5 images in 1989, 2000 and 2010 and landsat8 images in 2016 were used as the basic data sources (table 1).

Table 1. The list of remote sensing image data in the study area.

| Date       | Data type | The track | Resolving power | Number of bands | Format  |
|------------|-----------|-----------|-----------------|-----------------|---------|
| 1989-08-02 | Landsat5 TM | 119/31    | 30              | 7               | GEOTIFF |
| 2000-07-31 | Landsat5 TM | 119/31    | 30              | 7               | GEOTIFF |
| 2010-08-12 | Landsat5 TM | 119/31    | 30              | 7               | GEOTIFF |
| 2016-08-28 | Landsat8 OLI-TRIS | 119/31    | 15              | 11              | GEOTIFF |

2.3. Data Preprocessing
In order to reduce the contrast error as much as possible, the summer remote sensing images of July and August with relatively less cloud cover are selected. Data preprocessing is carried out under ERDAS IMAGINE 9.2 software platform. According to the specific land cover characteristics and the resolution, the best remote sensing band image is selected. In 1989, 2000 and 2010, three bands of R4G3B2 were selected to form standard false color image, while R5G4B3 was selected for 2016 image. Then, taking an image after fine correction as the benchmark, the quadratic polynomial model is used for geometric correction, and the correction error is no more than 0.5 pixels. Finally, the study area is obtained by cutting the image according to the scope of the study area.

2.4. Land Cover Classification
Land cover classification is the basic premise of remote sensing image interpretation, land pattern and land use dynamic analysis. At present, there are many classification methods commonly used, including: maximum likelihood classification, artificial neural network classification, support vector machine classification, decision tree classification, object-oriented classification and so on [1]. These methods have their own advantages, and have been widely used in their advantageous areas [10]. Among them, the classification method of facial objects is widely used, which can effectively avoid the occurrence of “salt and pepper phenomenon”, but it also faces the problem of complex segmentation scale, which requires higher requirements for users [11].

Although the maximum likelihood method is not the latest method, it has the advantages of mature and simple algorithm, fewer parameters to be adjusted in the classification process, and fast operation speed. Under the large sample method, it can still achieve enough accuracy [1, 12]. Therefore, this paper uses the maximum likelihood method to further explore the potential of Landsat series data in land cover information extraction.
According to the standard of Land Use Status Classification (GB/T 21010-2017) and the geomorphologic characteristics of Shenyang area, this paper divides the land cover types into five categories: water area, construction land, cultivated land, forest land and other land. Based on ERDAS software, the training samples are selected and the classification template is established. The maximum likelihood method is used for supervised classification of all images. Through cluster analysis and removal analysis, the classification results of the study area are obtained after removing various miscellaneous points and small spots.

In order to accurately evaluate the accuracy of the results, a random sampling method was used to generate 300 random points in each of the four stages of land cover classification map. Then, with the help of Google Earth data, combined with visual interpretation and field investigation results, the results are compared with the supervised classification results of random points one by one. Finally, the classification accuracy report is generated, and the evaluation results of image classification accuracy are shown in table 2.

Table 2. Overall accuracy and Kappa coefficient of four phase image classification.

| Year | 1989 | 2000 | 2010 | 2016 |
|------|------|------|------|------|
| Overall accuracy (%) | 85.33 | 86.67 | 88.33 | 86.38 |
| Kappa coefficient | 0.8152 | 0.8312 | 0.8426 | 0.8266 |

It can be seen from the table that the overall accuracy after classification is better than 85%, and the Kappa coefficient is better than 0.8. They meet the accuracy requirements of land cover status information extraction. The results show that the maximum likelihood method is a very effective and accurate classification method for land cover change. This is due to the simple geomorphic unit, easy to identify land type and not broken, and the terrain is not undulating. The density distribution function of ground objects in each band of remote sensing image is approximately normal distribution, which has good statistical characteristics and is very suitable for classification by maximum likelihood method [8].

Through the comparison and analysis of the experimental data [5] made by predecessors in Shenyang area (table 3), it is found that the overall accuracy and Kappa coefficient of this experiment have been improved. This shows that under the condition of taking certain technical measures, relying on the classification method of maximum likelihood method, the potential of Landsat series data in land cover information extraction can be further improved.

Table 3. Comparison of classification results of this experiment with other results.

| Classification Objects | Previous data [5] | Data from this paper |
|------------------------|-------------------|---------------------|
|                        | 2000TM 2005TM 2010TM | 1989TM 2000TM 2010TM 2016 OLI-TRIS |
| Overall accuracy       | 84.67 85.94 85.40 | 85.33 86.67 88.33 86.38 |
| Kappa coefficient      | 0.8 0.8 0.8     | 0.8152 0.8312 0.8426 0.8266 |
| Method                 | Supervised classification | Maximum likelihood classification |

3. Analysis

3.1. Land Cover Structure

The interpretation results of land cover classification are transformed into vector maps, and the spatial overlay analysis is carried out on ArcGIS 10.2 software platform to obtain the conversion map of land cover types. The land cover data in 1989, 2000, 2010 and 2016 were obtained by using the overlay analysis results (table 4).
Table 4. Land cover and proportion in different periods of the study area. (Area: square kilometers).

| Year | Water area | Construction land | Cultivated land | Forest land | Other land |
|------|------------|-------------------|----------------|-------------|------------|
| 1989 | area       | 23.59             | 346.80         | 895.09      | 1321.01    |
|      | proportion (%) | 0.69             | 10.13          | 26.14       | 38.59      |
| 2000 | area       | 52.65             | 448.24         | 1045.12     | 1292.90    |
|      | proportion (%) | 1.54             | 13.09          | 30.53       | 37.77      |
| 2010 | area       | 55.51             | 1311.02        | 972.33      | 967.87     |
|      | proportion (%) | 1.62             | 38.30          | 28.40       | 28.27      |
| 2016 | area       | 48.40             | 1365.18        | 1181.82     | 738.02     |
|      | proportion (%) | 1.41             | 39.88          | 34.52       | 31.56      |

Compared with the data of corresponding years in Shenyang statistical yearbook, it is found that the data interpreted in the experiment is very close to the statistical data, and the change trend of the two is similar. This shows that the land classification method selected in the experiment is reliable and the results are credible.

The water area of Shenyang urban area has little change. The construction land area increased greatly during 2000-2010, and the increase amount was less in other periods. The overall change of cultivated land area was not big, and the area of forest land and other land use decreased significantly during 2000-2010.

3.2. Analysis of Land Cover Dynamic Degree

Based on the interpretation in different periods, the dynamic degree of land cover in Shenyang from 1989 to 2000, from 2000 to 2016 and from 1989 to 2016 is obtained (table 5).

Table 5. Dynamic degree of land cover in Shenyang (%).

| Time interval | Water area | Construction land | Cultivated land | Forest land | Other land | Comprehensive Dynamic degree |
|---------------|------------|-------------------|----------------|-------------|------------|------------------------------|
| 1989-2000     | 11.21      | 2.66              | 1.52           | -0.19       | -2.74      | 0.74                         |
| 2000-2010     | 0.54       | 19.25             | -0.70          | -2.51       | -8.00      | 2.53                         |
| 2010-2016     | -2.13      | 0.69              | 3.59           | -3.96       | -3.81      | 1.28                         |

It can be seen from table 5 that the dynamic degree of Shenyang from 2000 to 2010 is the largest, reaching 2.53%. This is in line with the rise of the real estate boom after 2000 and the rapid change caused by the influx of a large number of people into urban areas. From 2010 to 2016, the dynamic degree of the period was the second, which was 1.28%. During this period, the real estate in Shenyang was still developing rapidly. From 1989 to 2000, the dynamic degree was only 0.74%, which was consistent with the development of Shenyang. The change of single dynamic degree is as follows: From 1989 to 2000, other land > construction land > cultivated land > forest land; from 2000 to 2010, construction land > other land > forest land > cultivated land > water area; from 2010 to 2016, construction land > other land > forest land > cultivated land > water area. It shows that since 2000, Shenyang has entered a period of vigorous urban development.

4. Conclusion and Prospect

Based on the image data and the interpretation of land cover, this paper analyzes the structural composition and dynamic change of land cover change in Shenyang City from 1989 to 2016. The conclusions are as follows:

1) In the process of land cover classification and extraction from remote sensing images, the maximum likelihood method is still a very effective and high-precision classification method for Shenyang urban area, which is a small area with simple geomorphic units, easy to identify land types and small relief.
By 2016, the construction land area was 39.88%, accounting for the largest proportion. The proportion of the rest of the areas was farmland > forest land > other land > water area. During the period of 2000-2010, Shenyang City expanded rapidly.

Although the maximum likelihood method can still meet the needs with certain accuracy, it can not hide that it is a relatively outdated classification method. In order to improve the classification accuracy of land cover, it is better to combine with object-oriented classification technology and hierarchical classification technology, or adopt more advanced and complex methods, which also poses higher challenges to the skills and equipment of the experimenters.

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