

The Application of DMC Data in Land Use Change of Beijing Area

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Abstract: Urban land use change is one of the most significant expressions of land use and land cover change (LUCC). Urban expansion is the major form of industrialization and urbanization.

Disaster Monitoring Constellation, short-formed DMC, is an international small satellite organization composed by seven countries. The data resolution it received is 32m. DMC can supply images of any place in the world and update the data fleetly by passing by the same place fluently every day.

This paper based on DMC data and Landsat TM images, analyzed the structural features and spatial patterns of land use change in Beijing in the past twenty years. Besides, the driving mechanism behind the change is also discussed from several aspects. The data used are one DMC data of Beijing with a spatial resolution of 32×32 m obtained on December on 12 October 2004 and two TM scenes with a spatial resolution of 30×30 m obtained respectively on 2 October 1984 and on 19 May 2001. These TM images and DMC data were geo-referenced and orthorectified, using field-collected ground control points. A hierarchical classification system of 25 land-cover classes was applied to the data under the support from Intergraph MGE (Modular GIS Environment). The interpretation method of TM images and DMC data adopted is manual interpretation, which is intensive and time consuming but can insure high classification accuracy.

Finally, based on the above data, the effect of DMC data in land use classification and change detection is evaluated such as the classification accuracy, the spatial veracity and the area precision.

Key words: LUCC; DMC; Urban Land expansion; Spatial distribution; Beijing Area;

1. Introduction

According to the experience of most parts of the world, the process of development leads to urbanization and this

will require that cities grow in size and use of land. Economic development, in some sense, is a process that shifts population from rural to urban. In the earlier stages, agriculture sector always constitute the predominate economy. Successful urbanization also requires the expansion of infrastructure. In short, the shifting population, the emergence of industry and the expansion of infrastructure all require the use of the land.

2. Study area

Beijing is China's principal economical and cultural center and one of the largest and fastest growing cities in Asia that covers an area of 16,800 square kilometers with a population of about 15 million. As the capital city of China, Beijing is the national center of politics and culture, as well as a transportation hub both nationally and internationally. For the last 20 years, the city of Beijing has experienced rapid growth in terms of population and spatial extent compared to other major cities in the region.

The study area ,Beijing city, extends between $39^{\circ} 28'$ and $41^{\circ} 05'$ north and approximately between $115^{\circ} 24'$ and $117^{\circ} 30'$ east. It consists of 18 distinct and has evident change in the formation from heartland to marginal area and periphery area.

3. Satellite images and reference data

The data used are one DMC data of Beijing with a spatial resolution of 32×32 m obtained on May 2001 and two TM scenes with a spatial resolution of 30×30 m obtained respectively on September 1984 and October 2004. The three images were extracted to cover the same region.

DMC is the shorted form of Disaster Monitoring Constellation that is an organization formed by Surrey Satellite Technology Co.,Ltd.. DMC adopt the newly satellite remote sensing technology and has many characters such as high spatial resolution、 short period of reaccessing and low cost . The area it can scan is $600\text{km} \times 600\text{km}$.

Reference data for ground control points and for accuracy assessment included topographical maps at a scale of 1:100,000. Socio-economic data comprising mainly statistical information regarding the city's population and economy were also used in this study. The image processing and data manipulation were conducted with the MGE software, which also incorporates Geographical Information System (GIS) function. Arc/Info was used for GIS statistical analyses^[1].

4. Methodology

Change detection and monitoring involve the use of multi-data images to evaluate differences in land use/cover due to environmental conditions and human actions between the acquisition dates of images.

There are two basic approaches for land use/cover change detection: (1) post-classification comparison, and (2) simultaneous analysis of multi-temporal data. Both approaches have their advantages and disadvantages.

Since high precision geometric registration of the multi-temporal image data is a basic requirement for change detection^[2]. Firstly, the 2001 Landsat TM image was rectified corresponding to the Krassovsky and UTM projection. Thirty ground control points (GCPs) and 10 check points, well distributed across the entire image, were located in the image and in the 1:100,000 topographical map covering the study area. A digitizing tablet was used to register the image to the topographical map. A finite element polynomial was used, resulting in an rms error of less than one and half pixel. The image was resampled to a pixel size of $30\text{m} \times 30\text{m}$, using the nearest neighborhood method, in order to maintain the radiometric properties of the original data. The other two images, Landsat TM and DMC, were geo-referenced to the 2001 image using approximately 30-50 well-distributed GCPs. Finite element polynomial equations were used. The 2004 image was resampled to a pixel size of $30\text{m} \times 30\text{m}$ using the nearest neighbor method and the DMC image was resampled to a pixel size of $32\text{m} \times 32\text{m}$ using the nearest neighbor method.

Visual interpretation and digitization of TM images at the scale of 1:100,000 were done to generate thematic maps of land cover under technical support from Intergraph MGE (Modular GIS Environment) software. A hierarchical classification system of 25 land-cover classes was applied to the data. The 25 classes of land cover were grouped further into 6 aggregated classes of land cover: croplands, woodlands, grasslands, water bodies, unused land and built-up areas including urban areas.

The interpretation of TM images and land-cover classification adopt manual interpretation. Compared to unsupervised clustering method based on spectral character of land surface, the manual interpretation of Landsat TM imagery is labor intensive and time consuming. The main advantage of this method is its capability to provide descriptive information on the nature of changes that occurs.

5. Results and Discussion

The land use/cover changes revealed for Beijing city occurred as a result of the interactions of a number of environment as well as demographic and socio-economic forces. The urbanization speed of Beijing city has been rapid compared to other major China cities.

1) Rapid economic development

Economic development has been one of the dominant driving forces and is the most important and fundamental factor for the urban land expansion. Beijing's per capita consumption expenditure was about 698 Yuan in 1984 and 8,923 Yuan in 2001 and 12,200 Yuan in 2004. Beijing's gross domestic product (GDP) was about 281.76 billion Yuan in 2001^[3] and 428.33 billion Yuan in 2004^[4]. The economic growth rate of 2004 is the fastest during the past ten years. The economic development has led to the establishment of more industries, the boom of real estate and subsequently to the expansion of the city area. With the economic development and the income increase, the need for the living condition and environment is greatly improved which provoke the city's requirement for land.

2) Urban population growth

The 1988 population census put Beijing's population at slightly 10.81 million. The population rose to 13.83 million by 2001^[3] and 14.92 million by 2004^[4]. The rapid urban population growth reflects a natural population increase among the urban residents as well as migration of people from rural areas to the city. This population growth has increased the demand for food and has led to intensification of agriculture and expansion of cultivated land. The population, which is growing at a high rate per annum, has contributed to the urban sprawl, the mushrooming slums, and the increased land use changes.

3) Traffic infrastructure

The spatial pattern of built-up areas has a geometry that has mainly been shaped by roads. Beijing is at the center of a series of radial roads and these roads link Beijing to other parts of the country. The road construction made great progress in 2001; the total length of the road in the city came to 4,200 kilometer in the end of 2001 and the ability of the traffic capacity is great improved. The investment on communications and transport was 14.88 billion that was about one third of the city's infrastructure construction investment^[3].

In short, the large-scale land use/cover change took place in Beijing area in the process of rapid urbanization from 1984 to 2004 with major characteristics of urban expansion at the expanse of encroaching cultivated land in the plain area and of obvious structural readjustment occurring in other land use/cover types. There existed obvious regional difference in land use/cover change in Beijing area during the past twenty years and the land use/cover change rate in exurb has already exceeded that in suburb in the before 21st.

Economic development that takes evolution of industrial structure and diffusion of population, as the center is the Internal motive force of urban land expansion, communication connection is the external driving force, and management and planning are intermediate forces.

The results also show that: with the error analysis and the image spatial resolution comprehensive analysis and geometry registration, the DMC multi-band data can be used to land use investigation in large area. The land use/cover of Beijing in the past twenty years shows that much plow land was invaded by the urban, the non-urban land configuration change was obvious and the urbanization is obvious etc.

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