Analysis on Urban Sprawl and Landcover Change Using TM, ETM+ and GIS

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Abstract: This study explores the temporal and spatial features near 67years (1934 –2001) and landcover change in last 14 years (1987-2001) in Shijiazhuang, China, based on 67-year time series data edited from historical maps, TM and ETM+ imageries by integrating GIS and remote sensing method. An index named Annual Growth Rate (AGR) is used to analyze the spatial features of urban sprawl, and Maximum Likelihood classification method is utilized to detect the land cover types change. At last, the relationship between urbanization and factors is analyzed.
Keyword: Urban sprawl; Landcover change; GIS; Remote sensing.

1. Introduction

In recent decades, the research on land use and land cover change has become an important aspect of the research of global change[1]. And, LUCC (Land use/ land cover change) was treated as one core project of the IGBP program. Also in the last ten years, much attention was paid to urban land use/land cover change because the ecosystem in urban area is significantly affected by human activities and has a close relation with the life of almost half of the population of the world[2].

Remote sensing techniques is widely used in detected the landcover changing since the remote sensing data were available, and gave out satisfied result[3].

There has a speedy development in China, especially in the east part in recent two decades. There are some researchers studied on urbanization, landcover change and impacts on environment of some supper big cities like Beijing[4], Shenzhen[5], actually it is big (or middle) cities that lead the primary part of development (like Shijiazhuang) and the studies of these big (or middle) cities are very few, so analyzing the features, dynamics and changing of these cites has a very important significant for the plan of other developing cities, even necessary for the plan of the whole country.

The object of the research is to find the features and patterns of urban sprawl and landcover change by the method of integrating GIS to remote sensing analysis.

2. Study area

Shijiazhuang lies in 114 ° 23 ′ -114 ° 42 ′ east, 37 ° 58 ′ -38 ° 60 ′ north, and the study area is 341.63km2. Within east of Taihang Mountains and south of Hutuo river, it has a very plain slope of 1.5‰ from northwest to southeast. Wind direction is often from northwest in winter and southeast in summer. Raining fall is mainly in summer time, about 56% of the precipitation (550 mm/yr).

It is the largest city of Hebei province as a center of administration, culture, economy and transportation. After the JingGuang and ShiTai railways were constructed at the first of 1900's, Shijiazhuang is the station that contacts the two railways. For the important location, it changed from a small village to a trade town and then became big gradually. At 1968, it turned to be the capital of Hebei province, then became more and more prosperous than any other history time. Now it has a population of 1.609 million (1999), with the area of 165.5km^2(2001). Major industries are medicine, chemistry, textile manufacturing, machinery, and other light industries.

3. Data

1) Satellite data

Two scenes of land sat image are collected for analyzing the landcover change during the period from 1987 to 2001:one is Land sat 5 TM image recorded on 29 June 1987, the other is Land sat 7 ETM+ image on 10 May 2001. Both of these two images were chosen on the fine and no cloud days, so they all in high qualities.

2) Maps and socio-economic statistics data

Multi-temporal maps were collected as possible, for analyzing the temporal and spatial characteristics of urban sprawl from 1934 to 2001, including in the city map of 1934 with scale of 1:70,000 produced by survey bureau of China; city state map of 1947 with scale of 1:15,000; topographical map of 1981 with the scale of

1:100,000 come from survey bureau of Hebei province; land use state map of 1991 and the scale is 1:150,000 that produced by land management bureau of Hebei province. A number of social statistics data such as Chinese geographic map series produced by the normal university of Northwest and map press of China in 1984, developing history of Shijiazhuang by the native planning bureau in 1994, development plan history of Shijiazhuang city (1994), yearly economics statistics reports of Hebei province (1978-1998) for discovering the relationship between urban sprawl and population or other factors.

4. Method

Based on these maps, images and social statistics, we combined the MapInfo GIS and RS to analyzing the urban sprawl patterns (including the temporal features and spatial patterns) during last 67 years (1934 –2001) and the landcover change during the rapidly urbanization period of 14 years (1987 – 2001).

1) Temporal features of urban sprawl

All the maps were processed to be in the same scale and same geographical coordinate for comparing and calculating by GIS. We got the data of area of city by 1934,1947,1981,1991,2001. From analyzing these data, temporal features of the urban sprawl were obtained and we found the increasing trend of urban area has a violent variation in the different history stages.

2) Spatial patterns of urban sprawl in different stages

We work from four maps and one scene of corrected images, overlay all five maps by the same geographical coordinate and scale for comparing, and then obtain the Spatial patterns (Fig.2). An index named Annual Growth Rate (AGR) was used to observe the change rate of each period for quantifying the urban sprawl, it was calculated by Eq.1,

$$AGR = \frac{UA_{n+i} - UA_i}{n \cdot TA_{n+i}} \cdot 100\% \qquad (1)$$

In Eq.1, TA_{n+i} means the whole area of the city in n+i year (including the suburban); UA_{n+i} means the urban area of n+i year; UA_i means the urban area of i year. Using the natural broken method for clustering analyze, we quantified spatial patterns.

3) Landcover change occurred in the latest 14yrs.

Geographical coordinate were performed at first. Then enhancement, including false color, K-T conversion and filter it by a 3*3 median kernel. The third is classification, the area was classified into nine types: urban; resident; arable land; vegetable land; tree land; orchard; grass; water; barren/sands. Using bands 1-5 and 7, a supervised classifier named maximum likelihood classification was used to classified and calculated each type in each year of the area, then output the landcover classification map of 1987 and 2001(Fig 3).

Accuracy assessment is performed using overall accuracy and Kappa index, the result is, overall accuracy of 1987 is 95.06% and 2001 is 79.45%, the Kappa index of 1987 is 0.938 and 2001 it is 0.731.

5. Results and Discussions

1) Temporal features and Spatial patterns of Urban sprawl in recent 67 years

urban area sprawled from 6.31km2 to 165.5km2 in area from 1934 to 2001, at a rate of 2.376km2/yr, it was sprawled in very high speed, especially in the last two decades, but in different stages there were different features and patterns.

The whole period was divided into four stages (Fig1): a. Slow growth stage (1934-1950); b. Rapid developing stage (1950-1955); c. Crawling increment stage (1955-1981); d. Speedy rising-up stage (1981-2001).

From these analysis, spatial patterns of urban sprawl can be categorized as 3 typical patterns (Fig2): 1), influenced by special purpose in special time, such as war time during 1934-1947; 2), urban sprawl intervened violently by administration, such as in the years of political movements; 3), normal growth in the stable society economic environment in the recent two decades.

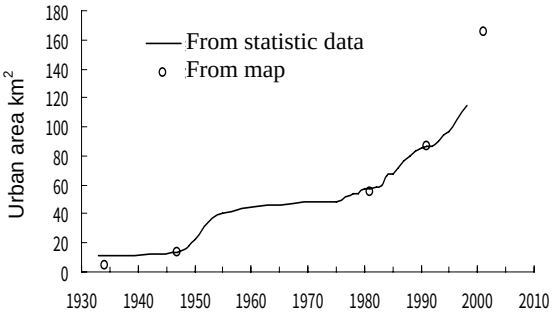

Fig.1 Temporal feature of urban sprawl in last 67yrs

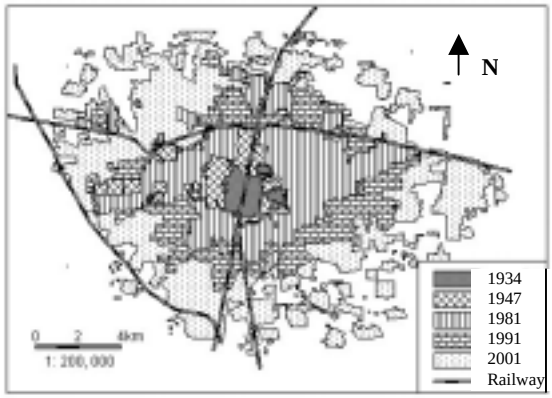

Fig.2 Urban area in different years

2) Land cover changes from 1987 to 2001

After the late of 1970's, construction of city raised quickly, not only the super biggest cities like Beijing, Shanghai, but also the big cities like Shijiazhuang even the small cities. These big and mid-big cities are the mainly developing strength in China, have a great potentiality. Urban area sprawled in a very high speed, as a result, landcover changing rapidly, and have impact on the local environment such as local temperature, ground water, urban flood, heat island and so on, so detecting the landcover change of the city like Shijiazhuang, has important meaning for guideline the urbanization of other cities.

From the classification map of these two years of Fig3, the types of landcover which area increasing fast are including in: urban, vegetable land, grass, water, and on the other hand, the types which decreasing fast are including in: tree land, orchard, arable land. Grassland has the biggest change rate and the next is water, although they are only a small part of the whole area, just 0.78% and 1.40%, it is a good trend of improving the city environment. Fact must be pay attention to that the rapid decreasing of arable land, tree land, orchard.

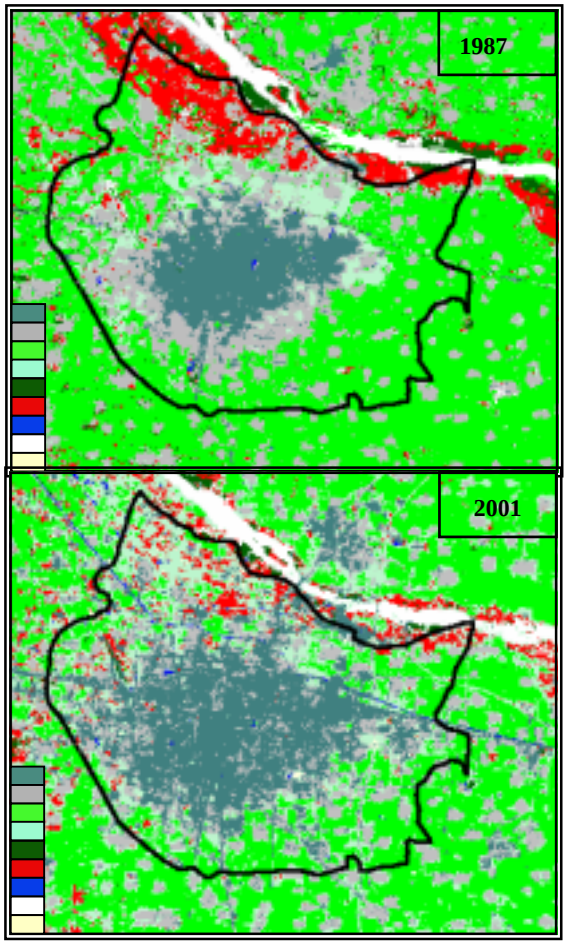

Fig. 3 The land cover classification map of Shijiazhuang in 1987 and 2001
1.urban; 2. resident; 3. arable; 4. vegetable; 5. windbreak trees; 6. orchard; 7. water; 8. barren/sands; 9. grass

3) Relationship of urban sprawl and some factors.

We chose four major aspects to analyze the mechanism of urban landcover change. They are population, transportation, whole production of industry, and the basic investigation, as indicated by the Fig4. We can obtain that the population is the most active factor of these four because there is a very good relationship between increment of population and sprawl of urban area, and three other factors are, too, have good relationships with the change of urban area.

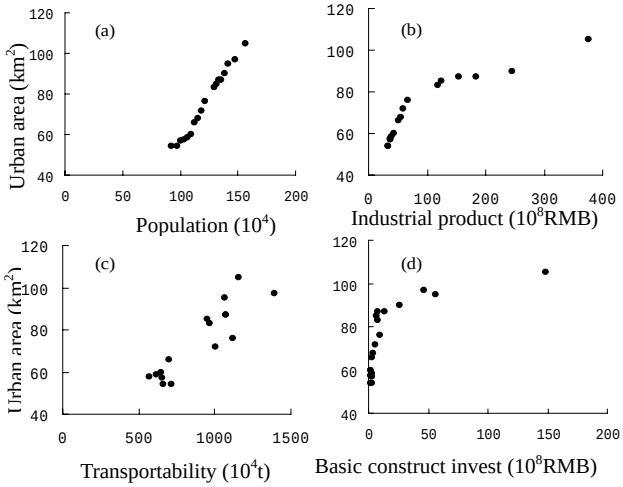

Fig. 4 The relationship between urban area and several main factors during 1978~1998

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