# STUDY ON URBAN LAND USE CHENGES BASED ON HIGH RESOLUTION REMOTE SENSING IMAGES

Jun Yin[a,b], Chenghu Zhou[a], Yingchun Gao[b], Junhui Zhang[b]

[a]Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China
[b]College of Urban and Rural Construction, Agricultural University of Hebei, Baoding 071001,China

**KEY WORDS:** Land subdivision, Image interpretation, Land use, Spatial analysis, Change detection, IKONOS, Urban, Aerial survey

**ABSTRACT:**

21century is an era of cities as the trend of urbanization has developed into the theme of globalization. China, as one of the most thickly populated countries will have a deep influence on the world for its urban development. With the help of the remote sensing software (PCI) and the geograhpic information system (ArcGIS) technology, the high resolution remote sensing images (for example aerial photo, IKONNOS, QUICKBIRD. etc)as basal information source, the present article makes a deep research on the urban land-use types, the urban land- use intensity and the urban land spatial use changes by interpreting the two issues of remote sensing images in 1994 (aerial photo and it's orthography) and in 2002 (IKONOS satellite image) in Shijiazhuang, based on the land-use change model in GIS. Results show: (1)the land-use types' percentage in Shijiazhuang is reasonable, and the function subarea is distinct; (2)during the period, the urban land-use area changed very fast during the period, among which the cultivated land decreased fast, while the green and the water area and residential area increased fast; (3)the comprehensive urban land-use intensity dynamic degree during the 8 years is 1.23%, the building area changes fast, among which the increased dynamic degree of land-use intensity of business and residential area increased are the most fast; (4)the increased building area increased by reconstruction of urban interior is bigger than that increased by urban expanding, the primary urban land-use change in Shijiazhuang has been exploring the latent power during the research period.

## 1. INTRODUCTION

Land Use Coverage Change (LUCC) is a study mainly about the land utilization changing system in terms of time and space, and sets up corresponding, representative models to explore and predict. Currently, LUCC has been discussed extensively both home and abroad, and its models are rather full-developed (Lambin, 2001; Shi et al., 2000; Bai, 2000). The limitation of remote sensing technology in regard of acquiring urban usable space restricted the study of traditional urban land use to urban land expansion, while the aspect is seldom touched regarding urban inner land change. As the commercialization of remote sensing data such as aerial photo images, IKONOS, QUICKEBIRD, of high resolution of under 1m is realized, the high resolution data with a high spatial resolution, and a wealth of spectrum information, contribute to locate the buildings and its changes of the space capacity, and interpret the information of urban land use. In this way, high remote sensing resolution imagery develops into the base of the research of urban land use, and its change as well.

Presently, the expansion of China's urban scale keeps growing, construction land gaining on the cultivated land constantly, triggering an embarrassment of human lacking land. Up till 31st, October 2006, the total cultivated land of China is 121.80 million hectares, reduced by $30.68\times10^4$ ha compared with 122.07 million hectares, merely 0.093 ha per capita. The sharp conflict of social economical development and urban land use curbed the sustainable development of the city as well as the society. The expansion of urban land scale, and the change of urban land use type as well, lead to a revolution to urban zone structure, producing a crucial impact on the urban developing course. The disciplines, regarding urban developing course and the evolution of urban land use chronological and spatial structure, should be followed to enhance the urban benign development, to realize the double win of economic development and the cultivated land reservation.

## 2. RESEARCH SCOPE, METHOD AND URBAN LAND USE TYPE

### 2.1 Research Scope and Method

The subject of the present research is the city of Shijiazhuang, includes 5 administrative regions—Xinhua Region, Qiaodong Region, Chang'an Region, Qiaoxi Region and Yuhua Region, covering an area of 144,150km$^2$. Remote sensing, geographic information system, and statistical method are assumed in data collecting and analyzing process. ArcGIS9.0version, PCI9.0 soft wares and man-machine interaction interpretation have been used in disposing the data, collected by the High Resolution Remote Sensing Image. The interpretation results are processed under the condition of GIS. The data of land use spatial and quality changes is availed by an exploration of the figure, 2 stage from 1994-2002, based on spatial overlays. The dynamic analysis of the changes of urban land use is carried on with the above conditions.

### 2.2 Urban Land Utilization Type Systems

The priority should be given to identifying the urban land use types in researching the changes of urban land use. Based on the reliability of Remote Sensing Imagery data, Urban Land Types and Planning Construction Land Standard and Present Land Utilization Classification, with the present research features, the study will focus on the 11 categories, including residential area (R), village area in cities (V), manufacture area (M), warehouse area (W), business area (B), public facilities

area (C), municipal facilities area (U), square and road area (S), green and water area (G), the cultivated land (F), other area (O), total land area (T). To attain an easy explanation and research on the features of district urban land use, based on Shijiazhuang urban planning map (1997-2010) and the Shijiazhuang comprehensive land value map (2002), the urban area is separated into 5 districts—Central District, North East District, South East District, South West District and South West District.

## 3. REMOTE SENSING DATA PROCESSING

### 3.1 Data Source Selection

The improvement of spatial resolution contributes to display more detailed geographic features, providing a base for using high resolution remote sensing imagery to inspect the geographic changes and human behavior. The present research availed itself of Aerial photographs ( June, 1994, white and black, spatial resolution 1 meter), and Data orthography map (DOM)(1:10000) as the main data source, and IKONOS satellite imagery (November, 2001, imagery data, panchromatic spatial resolution 1 meter, and Multi Spectrum spatial resolution 4 meters) as the basic data source, and PCI software, which works in disposing the remote sensing imageries, then interpret the information of urban land use and analyze it with the help of ArcGIS. The research also refers to Shijiazhuang City Planning Map (1997-2010), Administrative Districts Map (2002), Shijiazhuang Urban District Normal Land Value Map, and part of urban cadastre data of 2002.

### 3.2 Remote Sensing Imagery Resolution

**3.2.1 Image Geometric Rectification:** Satellite data rectification. The defect of IKONOS panchromatic wave's floor resolution of 1 meter demands an orthographic rectification to the image data, by means of digital differential rectification, in practice, surveying open field in line with GPS, or selecting reference points form precision satisfied geographic maps, choosing 12-15 points, calculating then setting up an rectified imagery pixel-coordinate. The error should be limited to under 0.5 cells in the rectified map. The tone in the rectified raster images should be resampled, adopting quadratic linear interpolation or cubic convolution interpolation in the present research.

The adopted aerial pictures of orthographic images, processed by geometric polynomial rectification, go through the process of projection transformation. The geographic coordinate relevancy theory is assumed to confirm the precision of the rectified IKONOS imageries and projected aerial pictures. To ensure the required overlapping precision of the current urban land use map after being categorized, the aerial pictures go through a second rectification with the processed imageries, to confirm the precise overlapping of the same objects in the two imageries. Tone sampling is carried on for the second time in line with bilinear interpolation.

**3.2.2 Imagery Highlighting:** Before the image merging, the IKONOS pan&multi-spectrum images should be highlightened. The readjusting process mainly aims to emphasize the detailed texture and lower the noise to the minimum, with the help of linear extension and high pass filter, so as to achieve ideal effect. To the black and white aerial photos, PCI soft ware was applied to the images by directional filter.

**3.2.3 Image Merging:** The present image merging assumed (IHS transform image fusion) to process IKONOS images, turning a pan-spectrum object of 1m high resolution and a multi-spectrum object of 4m resolution into one multi-spectrum object of 1m high resolution, so as to improve image spatial resolution, the image geometric precision, and the quality of characteristic expression.

## 4. URBAN LAND USE INFORMATION ABSTRACTION BASED ON REMOTE SENSING

### 4.1 Urban Land Utilization Types Interpretation Marks

Cities (and towns) refer to the residential areas of non-agricultural industries and non-agricultural residency. Urban land utilization currently indicates the process of land exploration, usage, and protection in the course of city construction and development. The essence of the process is to change the function of land use, viz. turning the cultivated land into urban construction and developing land, reading the basic forms of the city planning and city inner function zone's regional difference.

The spatial complex building information in urban were recorded by IKONOS and aerial images (DOM), then with the help of land object reflection spectrum quality, considering the features of floor objects' size, form, shadow, structure, location concerned, structure shape and so on, and the corresponding relation between image tone, image colour and texture system, and a comprehensive analysis to identify the floor objects, the city land use types undergo remote sensing interpretation (Mesev, 1998; Zhang, et al., 2002; Liao, et al., 2006). The structure complexity of urban landscape, poses great difficulty to interpretation, so, the original land use classification data were referred in fixing the types of unknown land. The priority should go to fix remote sensing marks according to the remote sensing image features and the relation between land and objects.

### 4.2 Method of Urban Land Use Intensity Sign Information Collection

The building floor area ratio, building density and building height reflect the urban land use intensity information. In this article, the building floor area is urban land use intensity. Building density is the ratio of building floor area and building unit coverage (the land types are clearly defined, the function is corresponsive to the land value). So, on the base of land use basic unit interpretation and classification, the building floor area (viz. building roof projected area) would be work out on the interpretation of its shadow texture, the tone difference and spectrum characteristics, reflected on the remote sensing images. Building intensity is the ratio between the building floor area and the unit land use area which is divided according to the space photos and Aerial photographs.

Given the floor is smooth, and the angle between the sun, the satellite height and the azimuth is fixed, a rigorous geometrical relation would be set between the floor building and the shadow of the building concerned. So, theoretically, once the space photo gives the size of the building shadow, its full height could be worked out easily, referring to the geometrical parameter between the sun and the satellite sensor(Huang, et al., 2004; Xie, et al., 2004; Cai, et al., 2006). During the operation, the

| Location | | R | V | M | W | B | C | U | S | G | F | O | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | AD | 3169.7 | 1131.3 | 2349.5 | 408.1 | 182.0 | 2370.5 | 351.1 | 1940.4 | 596.4 | 1706.5 | 209.4 | 14414.9 |
| | CD | 368.4 | 102.7 | 40.4 | 0.0 | 87.0 | 188.7 | 6.0 | 202.3 | 24.9 | 0.0 | 1.7 | 1022.1 |
| | NE | 389.9 | 267.7 | 1045.5 | 151.9 | 2.2 | 191.0 | 111.3 | 350.6 | 83.6 | 390.1 | 38.1 | 3021.9 |
| | SE | 826.6 | 247.3 | 396.3 | 141.6 | 52.6 | 414.7 | 83.0 | 449.3 | 145.6 | 514.5 | 43.7 | 3315.3 |
| | NW | 986.2 | 306.2 | 507.8 | 77.1 | 37.2 | 1081.9 | 42.2 | 453.4 | 205.2 | 517.3 | 70.9 | 4285.4 |
| | SW | 598.7 | 207.2 | 359.5 | 37.4 | 2.9 | 494.2 | 108.6 | 484.8 | 137.1 | 284.5 | 55.1 | 2770.1 |
| 2002 | AD | 3617.5 | 1041.2 | 2402.6 | 434.1 | 323.6 | 2425.8 | 363.0 | 2006.5 | 731.6 | 767.4 | 301.5 | 14414.9 |
| | CD | 374.5 | 88.6 | 40.4 | 0.0 | 111.0 | 174.0 | 6.0 | 205.6 | 22.1 | 0.0 | 0.0 | 1022.1 |
| | NE | 415.1 | 258.2 | 1069.9 | 158.8 | 2.2 | 231.2 | 111.3 | 354.1 | 88.7 | 240.5 | 91.8 | 3021.9 |
| | SE | 942.4 | 232.7 | 405.0 | 139.9 | 82.5 | 389.6 | 88.1 | 490.4 | 295.8 | 219.5 | 29.5 | 3315.3 |
| | NW | 1196.8 | 274.7 | 520.6 | 98.0 | 73.0 | 1166.3 | 46.7 | 458.2 | 206.6 | 177.4 | 67.1 | 4285.4 |
| | SW | 688.8 | 186.9 | 366.7 | 37.4 | 54.8 | 464.7 | 110.9 | 498.3 | 118.4 | 130.0 | 113.1 | 2770.1 |

Tab. 1 The area of urban land use change of 5 different region in Shijiazhuang city from 1994 to 2002 unit: ha

| Location | | R | V | M | W | B | C | U | T |
|---|---|---|---|---|---|---|---|---|---|
| 1994 | AD | 4476.80 | 972.71 | 650.94 | 110.69 | 217.61 | 1208.14 | 74.67 | 7711.55 |
| | CD | 569.26 | 82.63 | 16.37 | 0.00 | 165.83 | 201.92 | 1.28 | 1037.29 |
| | NE | 540.42 | 200.98 | 297.09 | 40.66 | 3.28 | 100.72 | 22.78 | 1205.93 |
| | SE | 1243.23 | 263.45 | 116.63 | 37.22 | 27.04 | 254.73 | 19.16 | 1961.47 |
| | NW | 1310.97 | 243.35 | 116.64 | 16.82 | 19.26 | 333.87 | 7.59 | 2048.51 |
| | SW | 812.92 | 182.30 | 104.20 | 15.99 | 2.20 | 316.90 | 23.85 | 1458.36 |
| 2002 | AD | 5663.85 | 897.27 | 660.50 | 131.24 | 392.39 | 1210.05 | 77.89 | 9033.20 |
| | CD | 666.51 | 72.19 | 16.37 | 0.00 | 258.79 | 215.19 | 1.28 | 1230.33 |
| | NE | 661.95 | 194.13 | 305.83 | 45.22 | 3.28 | 118.66 | 22.85 | 1351.92 |
| | SE | 1551.39 | 242.96 | 116.83 | 43.74 | 64.07 | 236.91 | 21.24 | 2277.14 |
| | NW | 1703.16 | 222.58 | 116.53 | 27.08 | 33.40 | 363.67 | 8.57 | 2474.99 |
| | SW | 1080.84 | 165.42 | 104.95 | 15.20 | 32.85 | 275.61 | 23.95 | 1698.82 |

Tab. 2 The building area of classified urban land of 5 different region in Shijiazhuang city from 1994 to 2002 unit: $10^4m^2$

sample building full height and its corresponding shadow size on the image could be located through spot surveying, then, the linear relation could be worked out between the building shadow size and its full height, again, in line with this, the full height of the building concerned. Based on the full height of the building concerned, the given time, and the unit floor height of different

building types, its floors could be calculated. The figure of total building area against unit building floor, is floor area ratio.

Because there is a divergence between the aerial photos and high resolution satellite images, in calculating the unit land utilization intensity change, the height of the building concerned is located by using the solid images' aerial photos of adjacent orbit. Parallax bar is used to get the parallax of the building concerned, then to get the height of the building and its unit floor height, in succession, the total construction area and the floor area ratio.

**4.3 Shijiazhuang Land Utilization Information Collection**

**4.3.1 2002 Urban Land Utilization Types and Intensity Interpretation:** Based on the former urban land use types interpretation marks, human-computer interaction with ArcGIS system is applied to the 2002 IKONOS images', to determine the districts respectively with the original signs and maps of urban land use types and planning, then define specific spots for each land type, in this way, to create the map of 2002 Shijiazhuang urban land use map and data (Tab. 1).

2002 IKONOS photos are used to interpret the urban land use intensity: first, draw the ichnography of the concerned buildings in the photos, to locate the building floor area information, then in line with the above mentioned building height calculating method, get the unit building's total construction area; second, superimpose the result onto the unit land use figure, then calculate the total construction area with the help of every pattern on the figure, and again work out the building floor area ratio through dividing the patterned building's total area by its corresponding unit area, and the building density by diving the patterned building floor area by its corresponding unit area, finally, add floor area ratio and density to the urban land use features ( Tab.2).

**4.3.2 1994 Urban Land Use Types and Intensity Interpretation:** Referring to the using remote sensing technology to update the land use current situation map(Yan, et al., 2002), with 2002 Shijiazhuang urban land use classification as the updating object base, comparing IKONOS photos and aerial photos by geographic coordinate relevancy method, two types changes are detected through visual interpretation, demonstrating changes in terms of unit land use intensity, but not land use types, and changes in terms of unit land use types (usu. intensity as well). Use unified land use classification criteria and indication to definite the former land use types, use sight parallax bar to land the information of the building's height and number of its floors, then infer its original unit urban land use intensity by exploiting the building floor area ratio, building density and building area.

By superimposing the change information figure and 2002 urban land use classification with ArcGIS system, 1994 Shijiazhuang urban land use classification figure is formed by using topology, including a complete set of information about land use types and land use intensity (Tab.1, Tab.2, Fig.1).

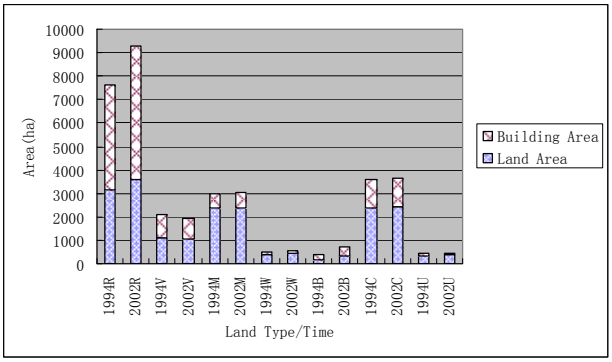


Fig.1 The area and building area of classified urban land of Shijiazhuang city from 1994 to 2002

**4.3.3 Interpretation Result Revision:** The application of 2002 Shijiazhuang urban land use concerned material and 1994 aerial photos drafts verifying remote sensing images is imposed to interpret the result, and revise it as well. In line with interpretation result, some specific district sampling field is chosen to confirm the result, proving that remote sensing interpreting urban land use types and land area rectification accuracy is over 90%, and that land use intensity (building floor number) interpretation has an accuracy of over 85%. The field investigation material shall be used to improve the results, as to elevate the relative accuracy.

## 5. SHIJIAZHUANG URBAN LAND USE CHANGE RESEARCH

Urban land use change research covers the following areas: the coverage changes of different urban land types, urban land use intensity changes, and urban land use spatial pattern changes.

### 5.1 Urban Land Use Types Coverage Changes

Coverage change firstly is reflected on urban land use total coverage. An analysis of the total coverage changes of different urban land use types tells its general trend and corresponding structure development. A study on the coverage of 1994 and 2002 different urban land use types shows the change scope during the 8 years (Tab. 1).

Table 1 shows, in the past 8 years, residential area expansion ranks first, with an increased area of 447.84 ha; the urban village area is reduced by 90.08 ha, now accounting for nearly 1/5 of the residential area; then business area and green and water area, increased by 141.59 ha and 135.20 ha respectively; warehouse area and urban planning increasing area rank last, of 25.95 ha and 11.96 ha. Among these, the cultivated land area shrank by the largest scale of 939.09 ha. According to the national Urban Land Classification and Programming Construction Land Use Criteria, construction land use program criteria contains construction land use per capita criteria, unit construction land use per capita criteria, and programming construction land use structure. Construction land use per capita criteria II is 75.1～90.0 $m^2$; unit construction land per capita of residential area, manufacturing area, square and road area, green and water area are18～28.0、10.0～25.0、7.0～15.0、≥9.0 $m^2$ respectively； programming construction land use structure of the above four types should account as 20～32、15～25、8～15 and 8～15％ of the total construction land, with a ideal whole proportion of 60～75％ between the four types area and the total construction land. Remote sensing interpretation demonstrates that at the end of 2002, in Shijiazhuang fully constructed districts, construction area per capita is 80.9$m^2$； and residential area, manufacturing area, square and road area and green and water area 26.17、13.50、11.27、4.11 $m^2$ respectively, taking up 32.32%，16.67%，13.92%，5.08% of the total construction area, totalling 68.00%.

The research data displays the fact that during the past 8 years, Shijiazhuang development assumes two main forms—outer expansion and inner reconstruction. The construction regarding residential, manufacturing, and square and road area fit in accordance with the national urban planning land use requirement, while green and water area failed to meet the requirement, so attention is demanded to increase green and water area in Shijiazhuang future urban land planning and construction.

On different regions of urban land use types indicates that distribution of each urban land use type has its own characteristic: besides the Central District, the residential area is mostly in the South East district and North West district, larger than the other two districts considering its absolute quantity, relative proportion and its increasing ratio, which is in accord with the urban planning development specification. Among the five regions, manufacturing area rate is highest in North East region, accounting 34.60% in 1994, and 35.40% in 2002

individually, while manufacturing area rate is lowest in Central region, staying at 3.95% during the 8 years. Business area rate ranks first in Central region, accounting 8.51% of its total coverage in1994, and 10.86% in 2002, which is also in accord with urban planning and land economy rule requirement (land rent bidding curve), that is central region as business area, while outer skirt regions as other use. The Central Region is central business area of the city, Shijiazhuang, with a comprehensive and intensive set of basic facilities and transportation network, holding the railway station and bus terminus. Warehouse area accounts highest in North East region and South East region. North East region is manufacturing area, where Shijiazhuang-Taiyuan railroad and Beijing-Guangzhou railroad intercross, carrying a great goods circulation. South East region highlights

this characteristic as further developing residential area, witnessing a much higher increase than the others, its green and water land mounting up to 8.92% of its region coverage. The public facility area accounts for the North West region to be highest, accounting 25.25% in 1994, and 27.21% in 2002 individually. The municipal facility area accounts for the North East region and the South West region to be highest, accounting 3.68% and 4.00% in 2002 individually, North East region is manufacturing area, the South West region is the university developed area, with a comprehensive and intensive set of basic facilities.

### 5.2 Urban Land Use Intensity Changes

Urban land use intensity change reflected in terms of urban capital intensity change and population intensity change. The present research uses the kinds of building area to indicate the change of land use intensity, Table 2 shows, the residential building area and the public building area are the biggest, accounting 62.70% and 13.40% in 2002 individually, the growing of the residential building area and business building area are the quickest, the rate of increment respectively is 26.52% and 80.32%. In all of the regions, the South East region and the North West region have the biggest residential building area, accounting 68.13% and 68.81% individually, the manufacturing building area rate is highest in the North East region, the building area of the two period of time occupy the total building area above 22%, the business building area rate is highest in the central region, the building area of the two period of time occupy the total building area above 15%,the warehouse building area rate is higher in the North East region and the South East region, accounting 3.34% and 1.92% individually. The public facility building area rate is higher in the Central region and the South West region, accounting 17.49% and 16.22% individually, in the Central region, the building area is big in government, the South West region is the new developing region of university. All kinds of the building area and the land area distribution rule are basically consistent, and accord with the urban planning requirement.

Shijiazhuang 8-year urban development engrossed a coverage of 939.09 ha of the cultivated land, while intensive development construction achieved as much as 2643.00 ha, the total construction area on the construction-taken the cultivated land accounted $521.08\times10^4 m^2$, while, intensive development construction added $800.57\times10^4 m^2$, the building area increase $1321.65\times10^4 m^2$ between this time.

### 5.3 Urban Land Use Dynamic Degree and Space Change

Urban land use dynamic degree refers to urban land use coverage dynamic degree and intensity dynamic degree, positive to predicting its development.

Urban land use coverage dynamic degree includes urban land use individual coverage dynamic degree ($K_i$) and urban land use comprehensive or general coverage dynamic degree ($LC_1$), urban land use intensity dynamic degree include two kinds as well, urban land use intensity individual dynamic degree ($K_j$)and urban land use intensity comprehensive change ratio ($LC_2$). The method refers to the formula used by the scholars of Xiulan Wang and Huiyi Zhu (Wang and Bao, 1999; Zhu, et al., 2001) (Tab.3).

| Location | | R | V | M | W | B | C | U | S | G | F | O | $LC_1$ | $LC_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AD | $K_i$ | 1.77 | -1.00 | 0.28 | 0.79 | 9.72 | 0.29 | 0.43 | 0.43 | 2.83 | -6.88 | 5.50 | 0.67 | 1.23 |
| | $K_j$ | 3.31 | -0.97 | 0.18 | 2.32 | 10.04 | 0.02 | 0.54 | | | | | | |
| CD | $K_i$ | 0.21 | -1.72 | 0.00 | * | 3.45 | -0.98 | 0.00 | 0.20 | -1.41 | * | -12.50 | 0.30 | 1.26 |
| | $K_j$ | 2.14 | -1.58 | 0.00 | 0.00 | 7.01 | 0.82 | 0.00 | | | | | | |
| NE | $K_i$ | 0.38 | -0.48 | 0.77 | 0.61 | 0.00 | 1.21 | 0.00 | 0.10 | 0.44 | -3.63 | 15.39 | 0.42 | 0.75 |
| | $K_j$ | 2.81 | -0.43 | 0.37 | 1.40 | 0.00 | 2.23 | 0.04 | | | | | | |
| SE | $K_i$ | 1.75 | -0.74 | 0.27 | -0.16 | 7.10 | -0.76 | 0.77 | 1.14 | 12.89 | -7.17 | -4.06 | 0.92 | 1.30 |
| | $K_j$ | 3.10 | -0.97 | 0.02 | 2.19 | 17.12 | -0.88 | 1.36 | | | | | | |
| NW | $K_i$ | 2.67 | -1.29 | 0.32 | 3.38 | 12.02 | 0.98 | 1.33 | 0.13 | 0.08 | -8.21 | -0.67 | 0.73 | 1.30 |
| | $K_j$ | 3.74 | -1.07 | -0.01 | 7.62 | 9.18 | 1.12 | 1.62 | | | | | | |
| SW | $K_i$ | 1.88 | -1.23 | 0.25 | 0.00 | 221.37 | -0.74 | 0.27 | 0.35 | -1.71 | -6.79 | 13.17 | 0.69 | 1.67 |
| | $K_j$ | 4.12 | -1.16 | 0.09 | -0.61 | 174.39 | -1.63 | 0.05 | | | | | | |

Direction：* indicates the denominator as 0 in the concerned calculation.

Tab.3 The change rate and relative change rate of urban land use in the Study Area from 1994 to 2002 unit: %

Table 3 shows, during the past 8 years, Shijiazhuagn witnessed a fast urban land use area change in its constructed regions, with a comprehensive change rate of 0.67%, among which, the cultivated area shrank fastest, reaching 6.88% per year, the business land went through a rapid increase, with a yearly growing rate of 9.72%; the increases of green and water area and residential area are the slower, with a annual elevating rate of 2.83% and 1.77%, the increases of manufacturing area and public facilities area are the slowest, yearly rising by 0.28% and 0.29%. The illustration proves that during the past 8 years, the rapid urbanization development took a much part of the suburb area, mainly for residential area construction, and spurring the expansion of green and water area as well; the manufacturing area principally located in the high and new technology industrial development zone, while little increases took place in the original constructed area.

In the above 5 regions, in respect of urban land use area comprehensive change rate, the biggest change happened in South East region, reaching 0.92%; then, North West region with an increase of 0.73%, both as residential area; while, the Central Region and North East region underwent the smallest changes; the central business area and industrial area development had achieved a certain achievement, so supposing

maintenance and improvement can further kept, little changes would be expected. Except the other types of land use, in respect of individual urban land use area change rate, the business area in South West region and the green and water area in South East region had experienced the fastest increase, arriving 221.37% and 12.89% respectively; while in respect of use land decreasing rate, the cultivated land in North West region and South East region experienced the fastest decrease, with a shrinking rate of 8.21% and 7.17%; both are potential residential area.

Table 2, 3 show, during the supervision, little changes took place in the constructed area regarding building intensity, while construction floor area ratio increased by 0.10, and the total construction area $1321.65\times10^4m^2$. Urban land use comprehensive change rate has a rapid change, with a rate of 1.23%. The intensity of business area and residential area experience biggest change, with a yearly average increase rate of 10.04% and 3.31%; in respect of urban land use intensity individual change rate, the urban village undergoes smallest change, with a yearly average decrease rate of 0.97%.

Among the 5 regions, South West region ranks first in respect of urban land use intensity dynamic degree, reaching 1.67%; next, South East region and North West region, increasing by1.30% equally; North West region witnesses the least change, with a rate of 0.75%. The residential area with a yearly increase rate of 4. 12% of South West region ranks first among the five regions; urban village reconstruction in Central region with a yearly increasing rate of 1.58% exceeds the other four regions; manufacturing area grows fastest yearly by 0.37% in North East region; warehouse area increases fastest in North West region, yearly 7.62%; business area in South West region and South East region, 174.39% and 17.12% respectively. Because at the beginning of the survey, business area took a rather small part in South West region, it is now under a rapid increase; public facilities area in North East region, by 2.23% every year; municipal facilities area in North West region, 1.62%, and South East region, 1.36%.

## 6. CONCLUSION

a. High resolution remote sensing imagery, giving accurate information of urban land use area changes, and relative intensity changes, and spatial changes, is an effective means of analyzing the urban land use change in city rapid development, basing for urban land use, city planning, and government administration.

b. During the supervision period, Shijiazhuang urban land use changes get more reasonable. Till the end of 2002, all the three standards of the constructed regions, including per capita panning construction area, per capita planning unit construction, and planning constructed land use structure, are mostly in accord with the national criteria. However, green and water area does not meet the national criteria, hence, more land should be set aside for green and water area in future city reconstruction and new land expansion.

c. The analysis of urban land use in the five regions shows that, in 2002, business area and business building area account for the top proportion of Central Region, the city's central business region; manufacturing area and manufacturing building area, the biggest in South East region, the city principal manufacturing region; residential area and residential building area, and green and water area, the biggest three proportion in South East region, the planning urban residential area; residential area and residential building area, and public facility area and municipal facility building area , relative higher among the land use types in North West region, and besides residential area, military installation area and other special use land also converged in the region; residential area, square and road area and municipal facility building area taking up relative bigger proportions in South West region, and in addition to universities assembled in this region, Beijing-Guangzhou railroad dispatching station installed in this region. The above demonstrations prove that function zones in Shijiazhuang are defined rather distinct and reasonable.

d. In the 8 years, the region-defined city of Shijiazhuang witnessed rapid changes concerning urban land use area, with its comprehensive change rate of 0.67%; among which, the cultivated land area shrank fastest by 6.88%; business area expansion grow fastest, 9.72% every year; next is the green and water area and the residential area, 2.83% and 1.77%; manufacturing area expansion slowest, just 0.28%. The change of comprehensive urban land use intensity was fast, reaching 1.23% in the 8 years; the intensity of business area and residential area experience biggest change, reaching 10.04% and 3.31%; next is the warehouse area, 2.32%.

e. Shijiazhuang 8-year urban development engrossed of 939.09 ha of the cultivated land, while intensive development construction took 2643.00 ha; the total construction area on the construction-taken the cultivated land accounted $521.08\times10^4m^2$, while, intensive construction $800.57\times10^4m^2$, therefore, the primary urban land-use change in Shijiazhuang has been exploring the inner redevelopment during the research period.

## REFERENCES

Eric F. Lambin, B.L.Turner, Helmut J. Geist, et al., 2001. The causes of land-use and land-cover change: moving beyond the myths. Globle Envirenmental Change 11, pp. 261-269.

Hong Cai, Jun Li, Jing Liu, 2006. The application of high spacial resolution RS image in kinematical monitoring of city development. *Yunnan Geographical Envirenment Research*, 18(1), pp. 106-109 (in Chinese).

Huiping Huang, Bingfang Wu, Miaomiao Li, et al., 2004. Detecting urban vegetation efficiently with high resolution remote sensing data. *Journal of Remote Sensing*, (1), pp. 69-74 (in Chinese).

Huiyi Zhu, Xiubin Li, Shujin He, et al., 2001. Spatio-temporal change of land use in Bohai rim. *Acta Geographica Sinica*, 56(3), pp. 253-260 (in Chinese).

Junfei Xie, Yanming Li, 2004. The extraction of building distribution informaration of different highs in a city from the shadows in a IKONOS image. *Remote Sensing for Land and Resources*, (4), pp. 4-6 (in Chinese).

Ke Liao, Xifang Cheng, Jiansheng Wu, et al., 2006. High resolution remote sensing image used in land use change dynamic monitoring. *Science of Surveying and Mapping*, (12), pp. 11-15 (in Chinese).

Mesev, 1998. The use of census data in urban imagine classification. *Photogrammetric Engineering and Remote Sensing*, 64(5), pp. 431-438.

Peijun Shi, Ji Chen, Yaozhong Pan, 2000, Land use change mechanism in Shenzhen city. *Acta Geographica Sinica*, 55(2), pp. 151-160 (in Chinese).

Qin Yan, Jixian Zhang, Xiaoxia Sun, 2002, Study on application of IKONOS imagery in dynamically monitoring land-use changing. *Science of Surveying and Mapping*, (2), pp. 40-43 (in Chinese).

Wanqi Bai, 2000. Analysis on land use dynamics of Shenzhen. *Journal of Natural Resources*, 15(2), pp. 112-116(in Chinese).

Xinchang Zhang, Lingling Zhao, Shaowan Yuan, 2002. A gis-based investigation and research for urban land use change. *Resources Science*, 24(5), pp. 70-74 (in Chinese).

Xiulan Wang, Yumei Bao, 1999, Study on the methods of land use dynamic change research. *Progress in Geography*, 18(1), pp. 81-87 (in Chinese).