ANALYSIS OF LAND USE CHANGE IN GUANGZHOU CITY BASED ON TM （1997－2003）

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ABSTRACT:

In this paper，it gave a detailed introduction about the classification process of land use in Guangzhou supported by RS and GIS software using the data of Landsat TM of 1997 and 2003. After being geometric corrected subset and enhanced, the images were classified into 9 classes as farmland, orchard, forest, disk-pond, urban and rural land, developing area, river, lake and unused land by using maximum likelihood classifier. The total classification accuracy was given at last. And then mathematic method was used to analyze the land use change by the conversion matrix, including the quantity changes, the speed changes, the space changes and the region difference.

1. INTRODUCTION

Land Use and Land Cover Change, listed LUCC, was jointly proposed by International Geosphere-Biosphere Program (IGBP) and International Human Dimensions Programme on Global Environmental Change (IHDP) in 1995. Since that, regional land use and Land cover change has become one of the global hot topics of research, and data access is an extremely important study of the basic work..

With the progress of urbanization accelerating , regional land use change in cities was studied widely from different angles, and abundant research results were achieved[1].RS and GIS are used to analyze spatio-temporal patterns of land use in the development corridor of the Pearl River Delta by LI Xia [5]. Studies on the urban grade size change of the Pearl River Delta based on remote sensing was done by HU Weiping[6]. Analysis of Characteristics of Land Use Change in the Pearl River Delta from 1978 to1998 was preformed by CHEN Shuisen[7]. In this paper, land use change of Guangzhou City from 1997 to 2003 will be analyzed.

2. STUDY AREA

The study area of this paper is Guangzhou city, which located in the central and southern Guangdong Province, the northern edge of the Pearl River Delta, close to the lower reaches of the Pearl River estuary basin, with the scope of his east longitude 112 degrees, 57 minutes to 114 degrees 3 minutes, Latitude 22 degrees 26 minutes to 23 degrees 56 minutes. There are broad plains in topography. And hilly land mostly lies in northern and eastern part.Guangzhou is comprised of ten city districts(Dongshan, Liwan, Yuexiu, Haizhu, Tianhe, Fangcun,

Baiyun, Huangpu, Panyu, Huadu) and two county-level cities(Conghua, Zengcheng).

Fig.1. The location of study area

3. DATA AND METHOD

In this study, Landsat TM images of Guangzhou (WRS path 122, row 44) are used on Aug.29, 1997 and Oct.17, 2003 respectively. The quality of images is good, with the research as auxiliary information.RS is the main research method while GIS is the auxiliary method. The process of project is as followed

area without clouds blocked. In addition，vector map and Land Use Planning from year 1997 to 2003 of Guangzhou are

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┌─────────────────────┐      ┌─────────────────────┐
│  Image of 1997(TM)  │      │  Image of 2003(TM)  │
└─────────────────────┘      └─────────────────────┘
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┌──────────────────────────┐   ┌─────────────────────────────────┐   ┌──────────────────────┐
│ Image of 2000 (ETM$^+$ │   │ The Pre-processing of RS Image │   │ Vector map of   │
│ with Gauss-Kruger   │   │   │   │ Guangzhou by   │
│ Projection and Beijing   │   │ ┌───────────────────────────┐ │   │ 1:1200000 scale   │
│ Coordinate System)   │   │ │ Geometric correction   │ │   └──────────────────────┘
└──────────────────────────┘   │ └───────────────────────────┘ │
                               │ ┌───────────────────────────┐ │
                               │ │ Image subset   │ │
                               │ └───────────────────────────┘ │
                               │ ┌───────────────────────────┐ │
                               │ │ Enhancement processing   │ │
                               │ └───────────────────────────┘ │
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RS Image Classification

Set up the classification system	Develop the interpretation mark	Establish the classification signatures	Perform the supervised classification	Do the post classification processing	Do the accuracy assessment of classification

Overlap the images, and determine the `transition` matrix of land use change

Analysis on land use change in Guangzhou

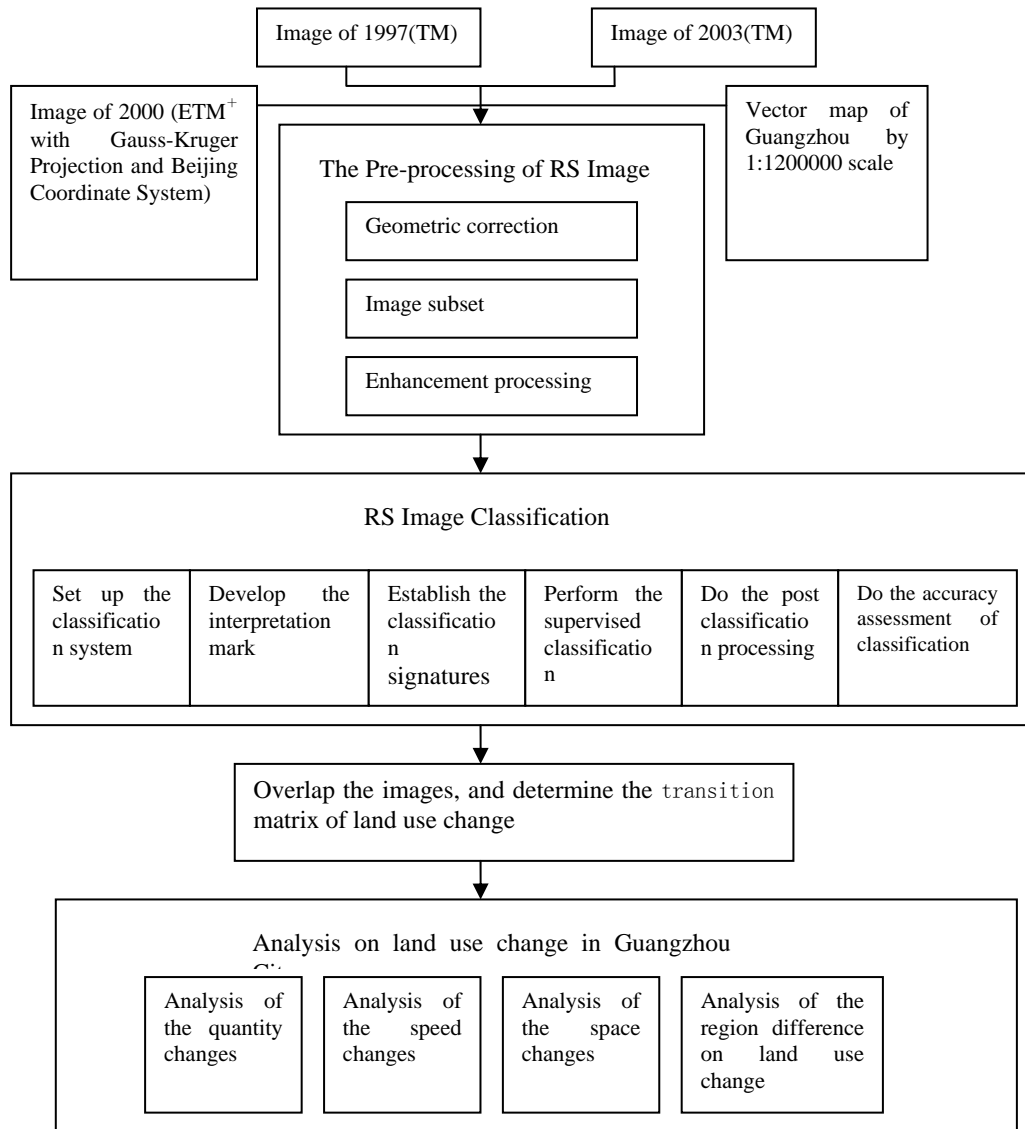| Analysis of the quantity changes	Analysis of the speed changes	Analysis of the space changes	Analysis of the region difference on land use change

Figure.2. The process of roject

4. THE PRE-PROCESSING OF RS IMAGE

In this study, geometric correction adjustment is using ground control points(GCP) to adjust the geometric correction of remote image by "map to map" method, and 45 GCPs have been chosen. The images of 1997 and 2003 both were rectified to the ETM$^+$ image of 2000 which adopted Gauss-Kruger Projection and Beijing Coordinate System. Secondly, to ensure the comparability between the two images, the image subset processing has been used. Next, in order to improve image quality and advance image recognition degree, enhancement has been processed before classification.

5. EXTRACTION OF THE LAND USE CHANGE INFORMATION

The classification System was formulated by the region characteristics of the land resource and social economy condition, which included farmland, orchard, forest land, pond, urban and rural land ,new development zone, river, lake and unused land. Interpretation mark is developed with vector map, investigation data and some other references.

supervised classification was performed using Maximum Likelihood method, and above 200 samples were selected respectively on the two images based on visual image interpretation and some data of investigation.

Since there are some influential factors, such as mixed pixel and the phenomenon of "same spectrum different target", some small spots were produced. Rejection of the small spots was done by the RS and GIS software. In addition, correction was also done by visual interpretation.

The accuracy of the two classified images was testified with a stratified random sampling method, and the overall accuracy reached 85.2% and 83.4% respectively, with Kappa coefficient reaching 0.826 and 0.813.

Based on fieldwork and visual interpretation of the whole Guangzhou City area, a supervised classification was performed using maximum likelihood method, and got the

classification images of two different times (1997 and 2003).   These classification images are followed as Fig4.
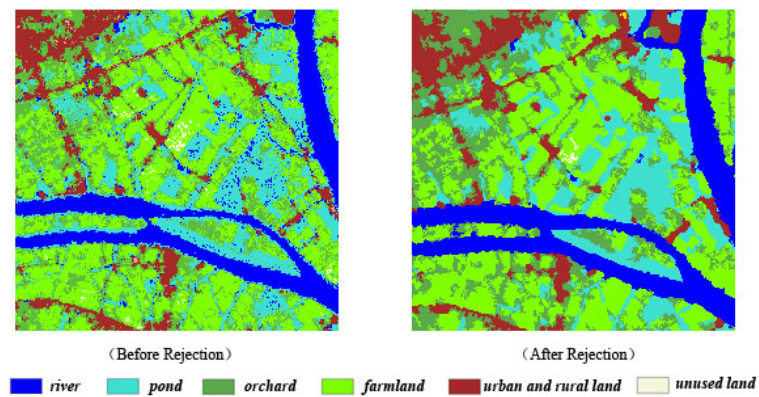

（Before Rejection）   （After Rejection）

■ *river*   ■ *pond*   ■ *orchard*   ■ *farmland*   ■ *urban and rural land*   □ *unused land*

Figure 3. The contrasts of classification before and after rejecting small spots

□ *unused land*
■ *lake*
■ *river*
■ *new development zone*
■ *urban and rural land*
■ *pond*
■ *forest land*
■ *orchard*
■ *farmland*

(1997)   (2003)
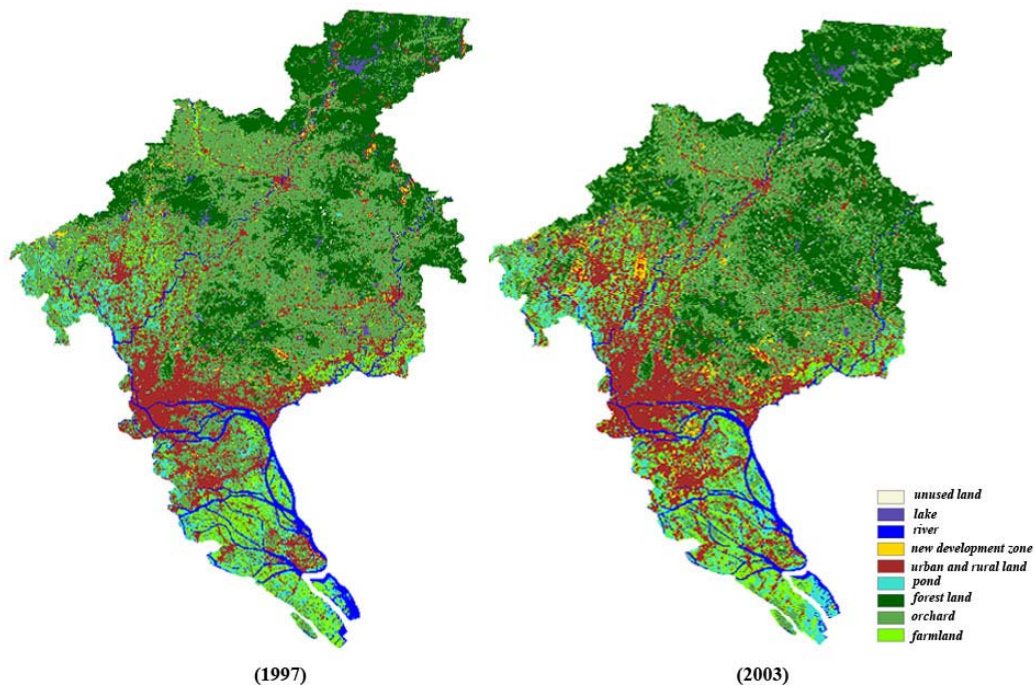
Figure4. The classification of TM 1997 and 2003

6. ANALYSIS ON LAND USE CHANGE

6.1 The Quantity Changes

According to the classification, areas of the land use are extracted. The results are as follows.
From Tab1 and Fig5 land use and change characteristics was concluded: 1）The characteristics of the change on the structure of land use in Guangzhou was that the change of farmland and forest land was not large, pond and unused land was reduced ,while orchard, urban and rural land and new development zone was increased. 2) urban and rural land was in large quantities，especially the urban land. from year 1997 to 2003, the area of urban and rural land was increased 24542.5 area of 7.53% with per capita share of farmland less than 0.007485 hectares. 5）land use types were in regional difference. Fig4 has shown that agriculture, forestry sites were

hectares. In 2003, urban and rural land accounted for the total land area of 19.8%．3) The forest land and the water surface account for a large proportion, and the environmental capacity was large. Forest land, river and lake of the city were 209908.9 hectares, total land area of 29.13%．As the forest and the water's tremendous ecological role, environmental purification in Guangzhou was strong and the environmental capacity was large. But, from year 1997 to 2003, both forest land and water area had different levels of reduction. 4）farmland was scarce and per capita area was limited. Although from 1997 to 2003, the farmland area increased by 69.73 hectares, in 2003 farmland area was only 54277.12 hectares, accounting for the total land

mainly in the northern and southern part while urban and rural land mainly in the central.

Year Land Use Type	1997		2003	
	Area（hectares）	Rate（％）	Area（hectares）	Rate（％）
Farmland	54207.39	7.5218	54277.12	7.5315
Orchard	277499.9	**38.5058**	256847.9	**35.6401**
Forest land	174956.5	**24.2769**	174266.8	**24.1812**
Pond	44026.49	6.1091	38057.37	5.2808
Urban and rural land	118162.2	**16.3961**	142704.7	**19.8017**
New development zone	15857.54	2.2004	19281.22	2.6755
River	26832.19	3.7232	26479.13	3.6742
Lake	8120.21	1.1268	7779.28	1.0795
Unused land	1008.1	0.1399	977	0.1356
Total	720670.5	100.0000	720670.5	100.0000

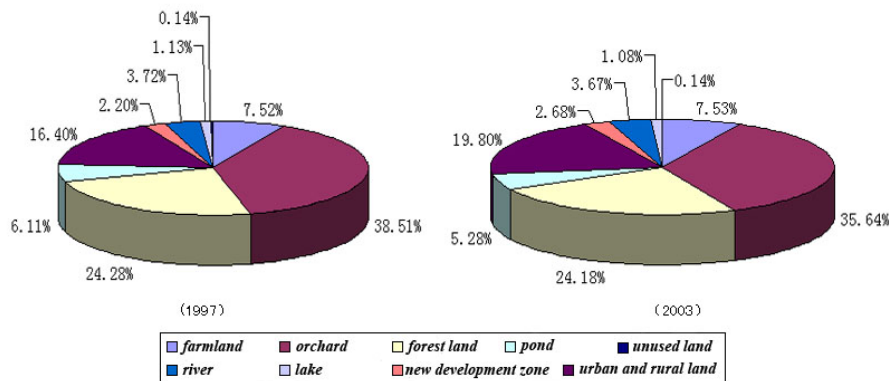Table.1. Statistic of land area in 1997 and 2003 （Unit: hectares）

Figure 5. The structure of land use in Guangzhou of 1997 and 2003

Land Use Type	Changes (hectares)	Change Rate （％）	Annual Changes (hectares)	Annual Change Rate （％）	Analysis
Farmland	69.73	0.1286	11.6267	0.0214	a little change
Orchard	-20652	-7.4422	-3442	-1.2404	Substantial reduction
Forest land	-689.7	-0.3942	-114.95	-0.0657	a little change
Pond	-5969.1	**-13.5580**	-994.8533	**-2.2597**	Substantial reduction
Urban and rural land	24542.5	**20.7702**	4090.417	**3.4617**	Substantial increase
New development zone	3423.68	**21.5902**	570.6133	**3.5984**	Substantial increase
River	-353.06	-1.3158	-58.8433	-0.2193	Few reduction
Lake	-340.93	-4.1985	-56.8217	-0.6998	Few reduction
Unused land	-31.1	-3.0850	-5.18333	-0.5142	Few reduction

Note: Changes means the real change area of every land use type from year 1997 to 2003. Change rate means changes in the overall level of every land use type in the 6 years. Annual changes mean the real average annual change area of every land use type. Annual change rate means changes in the average annual level [8].

Table 2. Statistic on the change of land use in Guangzhou from 1997 to 2003

6.2 The Speed Changes

The calculation of data taken from the study result was carried out, and some figures and tables about land use changes of Guangzhou were drew.

Tab2 and Fig6 have shown that new development zone and urban and rural land had the highest annual change rate, reached 3.5984% and 3.4617% respectively. orchard and pond had the second highest annual change rate，reached 2.2597%
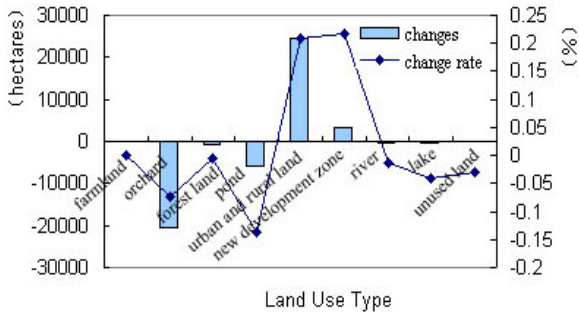
and 1.2404% respectively. The comprehensive average annual

Figure.6. The annual change and change-rate of land use in
Guangzhou from 1997 to 2003

change rate was quite quick，reached 1.32%.

6.3 The Space Changes

Markov transferring matrix is one of the models to quantitative describe the conversion of land use change, which help us to better understand the Spatial-Temporal features of land use[9].

2003 / 1997	Farmland	Orchard	Forest land	Pond	Urban and rural land	New development zone	River	Lake	Unused land
Farmland	47865.13	1170.88	113.84	27.10	3734.89	1192.56	32.52	0.00	70.47
Orchard	4773.00	248140.41	4828.50	416.25	15761.99	3357.75	111.00	0.00	111.00
Forest land	682.33	1452.14	167380.88	0.00	2519.37	2816.80	0.00	0.00	104.97
Pond	286.17	1536.52	1131.48	38593.62	1518.91	942.17	17.61	0.00	0.00
Urban and rural land	484.47	957.11	862.58	0.00	115858.04	0.00	0.00	0.00	0.00
New development zone	90.39	191.88	136.37	0.00	3019.28	12419.63	0.00	0.00	0.00
River	64.40	24.15	42.93	34.88	53.66	93.91	26410.92	0.00	107.33
Lake	12.99	242.79	21.11	22.74	0.00	23.55	0.00	7779.97	17.05
Unused land	27.72	18.95	55.55	1.41	144.46	91.03	0.00	0.00	668.98

Table 3. Conversion matrix of land use types in Guangzhou area during 1997-2003 （Unit: hectares）

2003 / 1997	Farmland	Orchard	Forest land	Pond	Urban and rural land	New development zone	River	Lake	Unused land
Farmland	88.3	2.16	0.21	0.05	6.89	2.2	0.06	0	0.13
Orchard	1.72	89.42	1.74	0.15	5.68	1.21	0.04	0	0.04
Forest land	0.39	0.83	95.67	0	1.44	1.61	0	0	0.06
Pond	0.65	3.49	2.57	87.66	3.45	2.14	0.04	0	0
Urban and rural land	0.41	0.81	0.73	0	98.05	0	0	0	0
New development zone	0.57	1.21	0.86	0	19.04	78.32	0	0	0
River	0.24	0.09	0.16	0.13	0.2	0.35	98.43	0	0.4
Lake	0.16	2.99	0.26	0.28	0	0.29	0	95.81	0.21
Unused land	2.75	1.88	5.51	0.14	14.33	9.03	0	0	66.36

Table 4. Conversion probability matrix of land use types in Guangzhou area during 1997-2003（%）

Tab3 and Tab4 have showed the conversion of land use change in Guangzhou from year 1997 to 2003: 1) Farmland mainly converted to urban and rural land, new development zone and orchard, and the conversion rate respectively were 6.89%, 2.2% and 2.16%. The main sources of converted farmland came from orchard and forest land. 2) Orchard, of which

15761.99 ha, mainly converted to urban and rural land, with the conversion reaching 5.68%. Also some part converted to forest land, farmland and new development zone, and the conversion rate respectively were 1.74%,1.72% and 1.21%. The increased parts of orchard mainly came from pond, forest land and farmland. 3) Forest land mainly converted to urban

and rural land and new development zone, of which 2519.37 ha to urban and rural land and 2816.8 ha to new development zone. The conversion rate were 1.44% and 1.61% respectively. Also, 2239.44 ha of forest land converted to farmland, orchard and unused land. The main sources of converted forest land came from orchard, which had 4828.5 ha change into forest land. 4) There was few pond convert to other land use types，with the whole convert area 5432.87 ha, of which 1536.52 ha converted to orchard and 1518.91 ha converted to urban and rural land. The converted pond was also few, only 502.38 ha. 5) The convert rate of urban and rural land and new development zone was low. But what converted to urban and rural land and new development zone were plenty，including farmland, orchard and forest land. 6) The convert rate of water (river and lake) was exactly low. And the unused land mainly converted to urban and rural land, with the convert rate reaching 14.33%.

6.4 The Region Difference

For the sake of study, we divided Guangzhou to three sub regions: urban district(Dongshan, Liwan, Yuexiu, Haizhu,

Tianhe, Fangcun, Baiyun, Huangpu), suburb(Panyu, Huadu), county urban district(Conghua, Zengcheng).

Relative land-use-change rate is one of the models of measuring regional difference of specific kinds of land-use-change. According to the formula [10], relative land-use-change rate of Guangzhou sub regions has calculated as Tab5.

Tab5 has showed the region difference of land use change in Guangzhou from year 1997 to 2003: For farmland, the relative change in urban district was the most obvious，and the relative land-use-change rate of county urban district was the second. Both surpassed 1. For unused land, the relative change in county urban district was the highest, while the suburb area was the second. For pond, the relative land-use-change rate of suburb was almost eight times that of county urban district. For urban and rural land and new development zone, the relative land-use-change rate in every district surpassed 1, especially the rate of urban district on new development zone reaching 2.165831. And the difference on orchard, forest land, and water (river, lake) was not significant.

Land Use Type	urban district	suburb	county urban district
Farmland	1.175785	0.969108	1.056445
Orchard	0.672575	0.928417	0.893687
Forest land	0.881944	0.892804	1.026807
Pond	0.107087	0.672173	0.08516
Urban and rural land	1.606661	**1.442105**	1.253342
New development zone	**2.165831**	1.345347	**1.273428**
River	0.963048	0.97452	0.988194
Lake	0.079126	0.095706	0.09358
Unused land	0.618664	1.054354	1.107466

Table.5. Relative Rate of Land use change in Guangzhou from 1997 to 2003

7. CONCLUSION

In this paper, two classified images were acquired after a supervised classification was performed using Maximum Likelihood method and the changes of land use were analyzed. From the analysis, it can be found that:

1) In 2003, the areas of orchard, forest land and urban and rural land were relatively large in Guangzhou. And different kinds of land use type had the characteristic such as uneven distribution and obvious difference.

2) The characteristic of the land use change on the structure was that the change of farmland and forest land was not large, and pond and unused land was reduced, while orchard, urban and rural land and new development zone was increased.

3) The change rate of new development zone and urban and rural land was the highest, while orchard and pond was the second. The comprehensive average change rate was quite quick.

4) The conversions of the land use were as follows: farmland mainly converted to urban and rural land, new development zone and orchard; orchard mainly converted to urban and rural land; forest land mainly transformed as urban and rural land, new development zone; the areas, which came from pond, urban and rural land, new development zone and water were few.

5) There was a little region difference on land use change.

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