Analysis of Land Use Change in Taiyuan City Based on Supervised Classification

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Abstract: The research area is Taiyuan City. Respectively using the 1995, 2005 and 2015 three periods remote sensing data, This adopt supervised classification that using the land change data of nearly 20 years as data source combined with the study area statistics after pretreatment. According to the results of the classification, we can get different periods of land use dynamic change and transition matrix after further processing. This article analyzes the change of land use type in Taiyuan. Finally, combination of the corresponding year of Taiyuan, regional GDP, national policy and other factors conduct comprehensive analysis. The one that gets the largest increase land is the land for construction, mainly transferred from the farmland and unused land, followed by woodland. The small portion of unused land and farmland turn to woodland. The water area has increased slightly. During 20 years land use types change are huge in Taiyuan, the level of urbanization continues to improve, the city's development is further reasonable.

1. Introduction

By analyzing and comparing the urban images within a certain period of time, the direction of development and the type of land use can be clearly identified. It is further possible to deduce the recent development direction of the city and to formulate a reasonable development plan [1]. Since the 1990s, land-use and land-cover change (LUCC) has gradually become an important basis for judging changes in global land types. Nowadays, it has become a frontier and hot issue in the study of global land use change. LUCC plays a key role in the development and rational utilization of land resources, as well as the coordinated development of ecology, environment and economy in various countries [2, 3].

This paper studies the land use change and development characteristics, spatial and temporal expansion direction and development rules of urban construction land in Taiyuan from 1995 to 2015 based on GIS and RS technology. Finally, the comprehensive evaluation and reasonable analysis of development trend in Taiyuan.

2. Study Area and data source

The urban area studied in this paper is Taiyuan City, which belongs to north China plain, Yellow River basin and central of Shanxi Province. According to geomorphic types, the city can be roughly divided into three parts: valley plain area, loess hilly area and rocky mountain - based three parts. The Fen River, the second largest tributary of the Yellow River, runs through Taiyuan from north to south, about 100 kilometers through Taiyuan. Average altitude of 800 m in downtown, the geographical coordinates are roughly between longitude 111 °00 '~ 113 °00' East, latitude 37 °00 '~ 38 °00' North. The total area of the region is about 1,460 square kilometers [4].

Taking Taiyuan City as the research object, this paper uses USGS (https://glovis.usgs.gov/) and Geospatial data cloud (http://www.gscloud.cn/) to download remote sensing image data. The GDP

and related population data of Taiyuan were obtained from China urban statistical yearbook. The auxiliary data is Taiyuan City boundaries.

3. Research methodology

3.1 Handling methods

Remote sensing images can be used to study the Land Use and Cover Change (LUCC) in the region, and can be used as a judgment basis for the spatial and temporal expansion direction and characteristics in the process of urbanization [5]. Landsat TM data contains 7 spectral bands, different ground objects have different reflection spectral response characteristics in different bands, and different grayscale values are presented with significant spectral differences in remote sensing images. It is convenient for the visual interpretation of remote sensing images to be clearer when they are supervised classification. The band selection should be based on the optimum Index method and the best application range method for each band of TM image [6, 7].

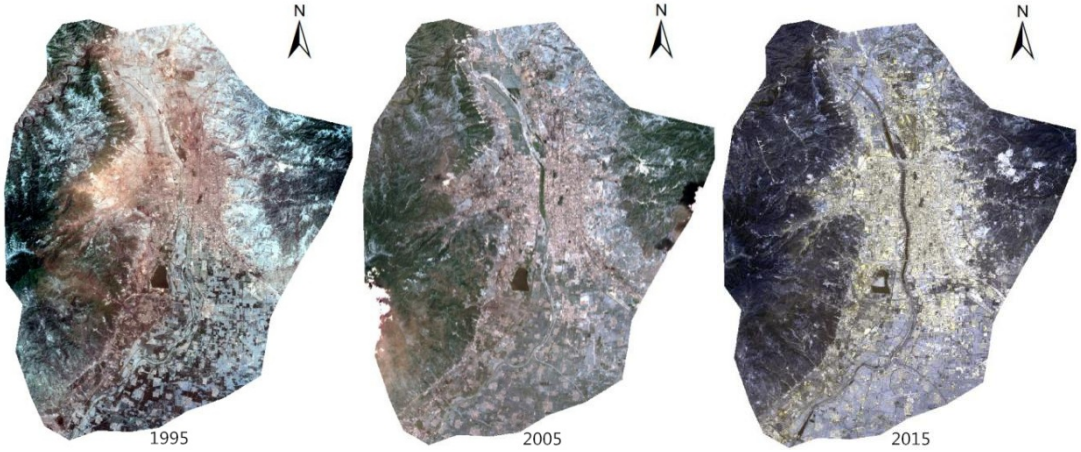

Figure 1. Remote sensing images of Taiyuan City in 1995 to 2015.

3.2 Image explanation

Before studying the image, it is necessary to eliminate the inevitable error of the sensor itself, need to use Radiometric Calibration and Atmospheric Correction. The images are shown in Fig.1. According to the actual situation of this paper, land use types are divided into five types: farmland, land for construction, waters, unused land and woodland. In this paper, the Maximum Likelihood (ML) method in supervised classification is used [8], and the remote sensing images of Taiyuan are classified according to land use types. Supervised classification is also called training field classification method. It is based on the classification template created by the research area, and the clustering judgment process of the remote sensing image is studied according to the system's certain classification decision conditions [9, 10]. In view of the classification of the terrain and land use status of Taiyuan, this paper adopts the interpretation method of human-computer interaction.

3.3 Supervised Classification

The classification template is established for the three remote sensing images. The supervised classification only obtains the preliminary results. It is needed to apply Post Classification method in ENVI [11]. Finally, using mask extraction, the final obtained the map of classification of land use status, as shown in Fig. 2. According to Kappa coefficient [12], it can be seen that the image classification effect is fine.

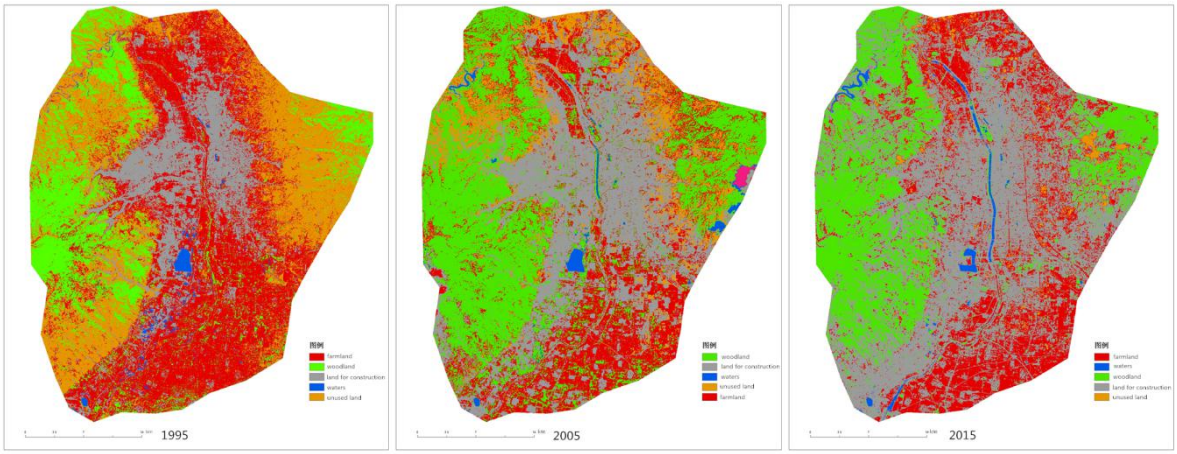

Figure 2. Spatial distribution of land use in Taiyuan City from 1995 to 2015.

4. Data analysis

4.1 Land use change

Table 1. Area and proportion of land use from 1995 to 2015.

Land-use types	1995		2005		2015	
	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)
farmland	537.48	32.97	359.51	22.05	287.1	17.55
woodland	256.85	15.76	471.49	28.92	586.15	35.84
land for construction	284.85	17.47	609.45	37.39	707.15	43.24
waters	13.53	0.83	15.87	0.97	16.68	1.02
unused land	537.5	32.97	173.85	10.66	38.37	2.35

It can be seen by combining Table 1. That the occupancy ratios of various types of land use, and the dynamic changes of the same type of land in the urban area of Taiyuan in the past 20 years. The farmland and unused land continued to decrease, and the farmland land decreased by 250.38km^2 in 20 years, with an average annual decrease of 12.52km^2. Unused land decreased most sharply during 1995-2005, mainly distributed in the undeveloped urban areas under the slopes in the east and west of the study area. The area of woodland, land for construction and waters has continued to increase. The land for construction grows the fastest. Woodland area increased by 311.3km^2, with an average annual growth of 15.57km^2, they're mainly in the mountains and the scenic areas in the urban area. The water area grows slowly. It can be seen from the images that farmland and unused land are the main sources of increase in other land use.

4.2 Land use transfer matrix

Land use transfer matrix [13, 14] is the transfer area of land use change type is listed in matrix form. It can reflect the mutual transformation between various land types. And understand the structural characteristics of land use types [15]. Shi et al. [16], they proposed the use of land algebra as the principle to obtain the land use transfer matrix method.

Table 2. Land use transition matrix of Taiyuan City from 1995 to 2015 (%).

		1995				
	Land-use types	woodland	land for construction	waters	unused land	farmland
2005	woodland	84.388	6.105	21.774	44.066	12.516
	land for construction	4.081	86.732	17.523	11.586	36.243
	waters	0.168	0.582	49.826	0.94	0.348
	unused land	2.28	1.782	0.104	26.215	7.643
	farmland	8.541	4.732	10.706	16.419	43.137
		2005				
	Land-use types	woodland	land for construction	waters	unused land	farmland
2015	woodland	63.895	1.36	4.317	5.947	4.721
	land for construction	29.76	85.457	36.375	7.294	51.745
	waters	0.277	0.832	53.319	0.393	0.451
	unused land	1.253	1.973	0.133	55.621	1.965
	farmland	4.755	10.325	5.806	30.645	41.034

We can draw a conclusion from the Table 2: From 1995 to 2015, the transfer rate of cultivated land was the highest at 58%, followed by unused land at 40.9%. This is closely related to the development and expansion of the research area in the past 20 years. The transfer of waters is mainly concentrated in land for construction and woodland. From 1995 to 2005, unused land was mainly transferred to woodland and farmland, while from 2005 to 2015; unused land was mainly transferred to land for construction and farmland. This indicates that the research area not only increases the conversion of unused land but also effectively protects used land resources.

4.3 Causes of changes

The continuous decrease of farmland in the study area in the past 20 years is closely related to the urban expansion and development. In this paper, the urban garden, lawn and other green land unified into the woodland. Greening was gradually emphasized during the period of urban development. Botanical gardens, national forest parks and other large areas of green space completed. The construction and renovation of urban parks have greatly increased green space.

Taiyuan is located in the loess plateau, water resources shortage and precipitation has been decreasing year by year in the past 20 years, these factors have a certain impact on the water area of the city. But in recent years, especially after 2010, Taiyuan expanded the area of the Fenhe River Basin. It not only overcomes the influence of geographical location defect and precipitation reduction, but also makes the water area of the study area increase year by year.

Table 3. GDP and population in Taiyuan from 1995 to 2015.

Time	Population/ Million	GDP/ Billion Yuan
1995	1.59	24.006
2005	3.42	89.549
2015	4.34	273.534

The expansion of urban population is one of the essential factors for urban development. As shown in Table 3, the population of Taiyuan increased from 1.59 million in 1985 to 4.34 million in 2015. The rapid increase of urban population raises the requirements of living facilities and public environment. In summary, the newly added construction land areas are mainly composed of cultivated land and unused land. Urban sprawl is mainly used to increase the area of land for construction by developing unused land.

5. Conclusion

In this paper, based on the remote sensing data, the land use types in Taiyuan City were classified by supervision classification, and relevant statistical data are combined. We draw main conclusions from the results.

The flat terrain in the south of the study area is dominated by plains, and the development direction of the city is mainly in the south, with scattered buildings gradually forming a whole area. The main land change is from farmland and unused land to woodland and construction land. Land conversion is obvious at the junction of cultivated land, woodland and unused land. Most of the water areas are gradually increased in the form of patches and scattered in the study area.

Land use change in Taiyuan is mainly affected by population, economy and local policies. The proportion and distribution structure of land use types in the whole city's land area are gradually reasonable. With the increase of government investment and construction and the gradual rise of the third industry, the urbanization level is above 80% and the urbanization level is significantly improved. The reasonableness of various land use types has gradually improved, and urban development is more reasonable.

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