

Urban Expansion Research Based on Multi-Temporal RS Information

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ABSTRACT Supported by remote sensing software ERDAS, this article studies the urban expansion of Dali city based on multi-temporal Remote Sensing information. Research process is proposed which includes three steps: data processing, classification, and change analyzing respectively. The land cover change of Dali city from 1989 to 1995 are calculated by RS information processing and classification. By contrasting analyses, some points of view about the urban expansion of Dali city are worked out. First, the urban expansion of Dali city was very obvious after six years development. The percentage of urban build-up area increased from 12.80% in 1989 to 15.73% in 1995. Urban expansion area mostly came from farmland (15.28%) and grassland (8.31%). Second, The essential reasons for the urban expansion of Dali city were the fast development in economy, large range adjustment in industry structure, constant increase in population, and improvement in living condition.

KEYWORDS Urban Expansion, Land Cover, Remote Sensing, Multi-temporal, Data processing

1. Introduction

As both the civilization symbol and the political, economical, and cultural center of human beings, urban attracts the natural and society resources around the urban region intensively. Since the policy of reform and open to the world was implemented, urban has expanded very fast in China along with the rapid development in economic, swift increase in foreign affairs, and speedy progress in urbanization. Although the development process and expansion pattern is different depend on the region, type, and scale of a city, study on the characteristics and rules of urban expansion is very important and necessary for urban planning and urban management. How to acquire the information, especially the spatial information of urban development effectively is a crucial problem for urban expansion research. With the characteristics of synthesize, macroscopic, and periodicity, Remote Sensing technique provides us perfect information source for urban expansion study.

Located in the southwest side of Erhai lake, northwest of Yunnan-Guizhou Plateau, and southwest of China, Dali city is a famous tourism city for tourists all over the world. Along with the rapid development of tourism and service trades, the urban expansion of Dali city had been very swift during 1990 years. Based on the multi-temporal remote sensing information (1989 and 1995 TM data), this paper will focus on the urban land cover change and urban expansion mechanism of Dali city development.

2. Research Process

According to the research object, possible information, and available equipment, the research process includes three steps: data processing, classification, and change analyses respectively (as shown in fig.1). And after that, the urban expansion mechanism is analyzed by using the society and economy statistical data.

2.1. Data processing

Supported by remote sensing software ERDAS, data processing step has been finished by means of geometric correction, histogram match, image enhancement, and so on. The results of data processing are "TM image of Dali city in 1989"(omit) and "TM image of Dali city in 1995"(omit).

2.2. Classification

Based on the Data processing images, land cover classification system has been determined firstly according to the characteristic of image and land use of Dali city region. The classification system composed of six types, such as urban build-up area, road & developing area, Farmland, forestry, grassland, and water body. Secondly, the signature pattern has been compiled by means of training sample selection and signature editor. Thirdly, by using maximum likelihood parametric rule, land cover classification scheme has been obtained through supervised classification with the signature pattern. The results of classification are "Land cover map of Dali city in 1989"(omit) and "Land cover map of Dali city in 1995"(omit). Finally, the area of each

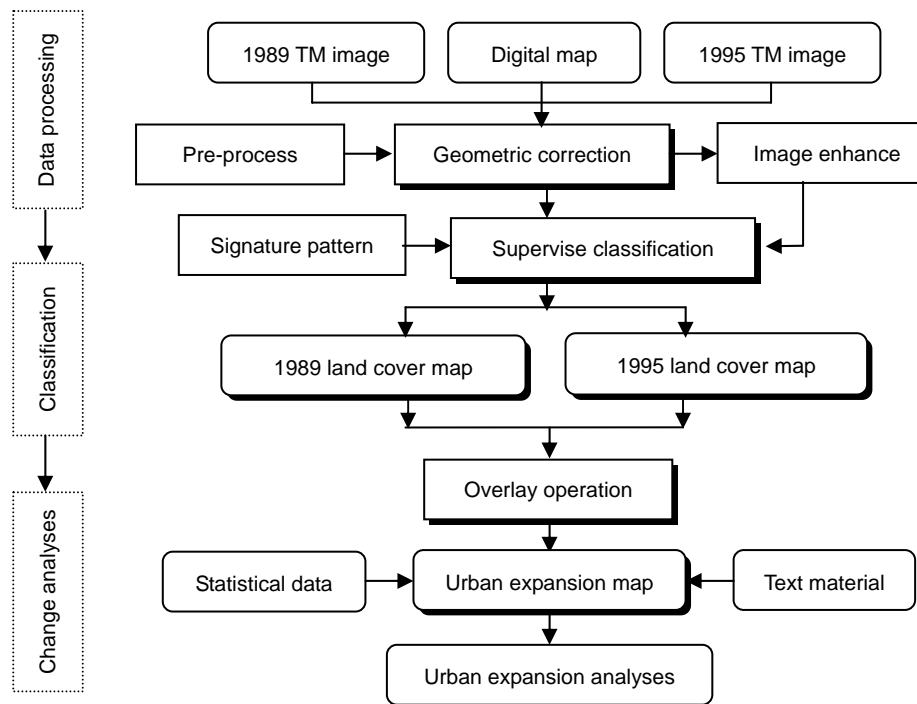


Fig. 1 Research process chart on urban expansion supported by multi-temporal RS information

land cover type is calculated by image pixel statistics. Table 1 and table 2 list the land cover statistics of Dali city in 1989 and 1995 respectively.

Tab.1 Land cover statistics of Dali city in 1989

Land cover	Number of pixel	Area (ha)	Percentage of area
Urban build-up	13374	1203.66	12.80
Road & developing	1414	127.26	1.35
Farmland	19741	1796.69	18.89
Forestry	25830	2324.70	24.71
Grassland	34265	3083.85	32.79
Water body	9888	889.92	9.46
Sum total	104512	9406.08	100.00
Sum total	104512	9406.08	100.00

2.3. Change Analyses

The change of each land cover type can be calculated based on the classification statistics, and are listed in Table 3. At the same time, the land cover change map of Dali city during 1989 and 1995 can be created by overlay analyzing of the land cover map in 1989 and 1995 (omit). Then, taking the land cover type in 1989 and 1995 respectively, the different land cover change statistics can be acquired, which are listed in table

4 and table 5.

Tab.2 Land cover statistics of Dali city in 1995

Land cover	Number of pixel	Area (ha)	Percentage of area
Urban build-up	16435	1479.15	15.73
Road & developing	4032	362.88	3.92
Farmland	15735	1416.15	14.99
Forestry	28369	2553.21	27.14
Grassland	29907	2691.63	28.62
Water body	10034	903.06	9.60

Obviously, while tables 1, 2, 3, 4, and table 5 list the quantitative statistical information, all of the land cover map and land cover change map express the spatial distribution information of Dali city development. By contrastive analyzing of all the spatial distribution and quantitative statistical information, the characteristics of ecological environment, land cover, and urban expansion of Dali city can be worked out as follows:

(1) Surrounded by Cangshan Mountain and Erhai Lake, Dali city possesses an advantaged geographic location and natural environment. Among the 9406.08 ha region area, water body area account for nearly 10 percent, and the

farmland, forestry, and grassland area totally account for more than 70 percent, while the urban build-up and constructing area only account for less

than 20 percent. The ecological environment of Dali city

Tab.3 Land cover change statistics of Dali city during 1989~1995

Land cover	1995 Area (ha)	1989 Area (ha)	Area change (ha)	Percentage of change
Urban build-up	1479.15	1203.66	275.49	22.89
Road & developing	368.82	127.26	241.56	189.82
Farmland	1410.21	1796.69	-386.48	-21.51
Forestry	2553.21	2324.70	228.51	9.84
Grassland	2691.63	3083.85	-392.22	-12.72
Water body	903.06	889.92	13.14	1.48
Sum total	9406.08	9406.08	0.00	0.00

region is very well because of more than 80 percent territory are covered with green vegetation and blue water.

(2) The land cover change of Dali city is tremendous after six years development. The percentage of urban build-up area increased from 12.80% in 1989 to 15.73% in 1995 (totally increased 22.89% during six years and annually increased 3.82%). The percentage of road & developing area increased from 1.35% to 3.92% (totally increased 189.82%). At the same time, farmland area decreased from 18.89% to 14.99% (totally decreased 21.51%, annually decreased 3.59%). Fortunately, the forestry area increased from 2324.70 ha to 2553.21 ha simultaneity (totally increased 9.87%).

(3) From 1989 to 1995, the urban expansion area of Dali city mostly came from farmland (account for 15.28%) and grassland (account for 8.31%), and the increase of road & developing area also came from farmland (account for 56.81%) and grassland (account for 12.37%). Correspondingly, the decrease of farmland mainly transformed to urban build-up area (account for 12.72%) and road & developing area (account for 11.79%).

(4) The area of road & developing land was 127.26 ha in 1989. When the time turned into 1995, 28.29% of the 127.26 ha had been transformed to urban build-up area, and another 21.57% had been transformed to farmland. The change from developing land to farmland is really a good sign although the result includes classification error.

(5) While many of the farmland was transformed to urban build-up and developing area, it was compensated by disafforestation and grassland reclamation. Among the 1410.21 ha farmland in 1995, 3.23% and 3.20% of it came from forestry and grassland in 1989 respectively.

(6) From 1989 to 1995, the increase of forestry mostly came from the decrease of grassland

(account for 27.14%). At the same time, a part of forestry (18.50%) was transformed to grassland. This situation indicated that tree planting and disafforestation behavior existed together.

(7) The spatial development direction or urban expansion direction of Dali city is mainly northeast which is related to topography, transportation, and economy development. Taking the topography condition as an example, three spatial directions of Dali city, such as west, south, and southeast are all mountainous area which restrict urban expansion. Only the northwest and northeast directions are mostly composed of plain. Furthermore, the transportation system, such as highway and railway are all located in northeast direction.

(8) The holistic spatial pattern of Dali city in 1995 was not rational enough because of urban expansion. It looks like a "huge cake" because of new suburban and older inner city was joined together. So, the traffic system was not effective enough, and the city function regionalization was not reasonable. In order to form pleasant human settlements, the better way is to construct a new town in the northeast region, which must be separated from older inner city with economic green land and be related to the older inner city with quick transport system and regional function

3. Mechanism Analyses

To analyze the mechanism of urban expansion and land cover change in Dali city, the authors have analyzed the social and economical statistical data in the same period (table 6).

Analyzing the statistical data listed in table 6, some points of view can be worked out. First, the gross domestic product increased 191.72% from 1990 to 1995, that means the average annual increase was 38.34%. Second, the tertiary industry increased very fast during 1990 to 1995, say, totally increased 306.69% during five years, and annually

increased 61.34%. Third, not as fast as the tertiary industry, the secondary Industry totally increased 164.35% during five years, and annually increased 32.87%. Fourth, the primary Industry changed a little, and the average annual increase was only 18.24% that was behind the average economy development. Fifth, the population increased 7.55%

during the five years, and the housing area per citizen increased 3.28%. Finally, the essential reasons for the urban expansion and land cover change during 1990 to 1995 were the fast development in economy, large range adjustment in industry structure, constant increase in population, and obvious improvement in living condition.

Tab.4 Land cover change statistics of Dali city during 1989~1995

1989 Land cover type	1995 Land cover type	Area (ha)	Percentage of area (%)
Urban build-up 1203.66 ha	Urban build-up	1066.68	88.62
	Road & developing	49.59	4.12
	Farmland	29.52	2.45
	Forestry	11.07	0.92
	Grassland	41.76	3.47
	Water body	5.04	0.42
Road & developing 127.26 ha	Urban build-up	36.00	28.29
	Road & developing	59.04	46.39
	Farmland	27.45	21.57
	Forestry	0.90	0.71
	Grassland	3.24	2.55
	Water body	0.63	0.49
Farmland 1776.69 ha	Urban build-up	225.99	12.72
	Road & developing	209.52	11.79
	Farmland	1262.70	71.07
	Forestry	18.99	1.07
	Grassland	5.94	0.34
	Water body	0.09	0.01
Forestry 2324.70 ha	Urban build-up	16.47	0.71
	Road & developing	4.59	0.20
	Farmland	45.54	1.96
	Forestry	1824.30	78.47
	Grassland	431.46	18.56
	Water body	2.34	0.10
Grassland 3083.85 ha	Urban build-up	122.94	3.99
	Road & developing	45.63	1.48
	Farmland	45.09	1.46
	Forestry	692.82	22.47
	Grassland	2154.78	69.87
	Water body	22.59	7.33
	Urban build-up	11.07	1.24

Road & developing	0.18	0.02
Farmland	0.18	0.02
Forestry	5.13	0.58
Grassland	0.99	0.11
Water body	872.37	98.03

Tab.5 Land cover change statistics of Dali city during 1989~1995

1995 land cover type	1989 land cover type	Area (ha)	Percentage of area (%)
Urban build-up 1479.15 ha	Urban build-up	1066.68	72.11
	Road & developing	36.00	2.43
	Farmland	225.99	15.28
	Forestry	16.47	1.11
	Grassland	122.94	8.31
	Water body	11.07	0.75
Road & developing 368.82 ha	Urban build-up	49.86	13.52
	Road & developing	59.04	16.01
	Farmland	209.52	56.81
	Forestry	4.59	1.24
	Grassland	45.63	12.37
	Water body	0.18	0.05
Farmland 1410.21 ha	Urban build-up	29.25	2.07
	Road & developing	27.45	1.95
	Farmland	1262.70	89.54
	Forestry	45.54	3.23
	Grassland	45.09	3.20
	Water body	0.18	0.01
Forestry 2553.21 ha	Urban build-up	11.07	0.43
	Road & developing	0.90	0.04
	Farmland	18.99	0.74
	Forestry	1824.30	71.45
	Grassland	692.82	27.14
	Water body	5.13	0.20
Grassland 2691.63 ha	Urban build-up	41.76	1.55
	Road & developing	3.24	0.12
	Farmland	59.40	2.21
	Forestry	431.46	16.03
	Grassland	2154.78	80.05

	Water body	0.99	0.04
	Urban build-up	5.04	0.56
	Road & developing	0.63	0.07
Water body 903.06 ha	Farmland	0.09	0.01
	Forestry	2.34	0.26
	Grassland	22.59	2.50
	Water body	872.37	96.60

Tab.6 Society and economy development statistics of Dali city during 1990~1995*

Indicators	Gross Domestic Product (10 ⁴ yuan)	Increase of Primary Industry (10 ⁴ yuan)	Increase of Secondary Industry (10 ⁴ yuan)	Increase of Tertiary industry (10 ⁴ yuan)	Total Population (person)	Housing area per citizen (M ²)
1990	92900	14599	52947	25354	435600	11.29
1995	271006	27916	139967	103113	468500	11.66
Increase of five year (%)	191.72	91.22	164.35	306.69	7.55	3.28
Increase of each year (%)	38.34	18.24	32.87	61.34	1.51	0.66

* Statistical data from 《Dali city statistic year book in 1997》 (China statistical press) .

4. Conclusion

Several conclusions can be summarized as follows through this research.

(1) Multi-temporal Remote Sensing data is the most effective information for urban expansion study. The research process includes three steps: data processing, classification, and change analyzing respectively. And image geometric correction technique is the key data processing step.

(2) The land cover change and urban expansion in Dali city are very obvious from 1989 to 1995. The percentage of urban build-up area increased from 12.80% in 1989 to 15.73% in 1995. Urban expansion area mostly came from farmland (15.28%) and grassland (8.31%).

(3) The essential reasons for the urban expansion and land cover change in Dali city during 1990 to 1995 were the fast development in economy, large range adjustment in industry

structure, constant increase in population, and obvious improvement in living condition.

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