

The Study on the dynamics of Landscape pattern in Xiangxi Region Based on RS/GIS

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Abstract. Xiangxi Region is on the edge of Yunnan-Guizhou Plateau which has complicated topography. It is a multi-nationality region which is the important protected area for resources and environment in China. Based on the data of Landsat TM/ETM image in 1990, 1995, 2000, 2005, 2010 and 2015, the change of landscape pattern in Xiangxi Region was analyzed by the use of ARCGIS and FRAGSTATS. The results showed that: (1)The area of farmland and forestland decreased. (2)The landscape patches in Xiangxi Region tended to be more fragmented and diversified but the shape of patches were more simple. (3)The fragmentation of farmland, building land and unused land was more serious. The patch shape of building land, water and wetland is more complicated. (4)These changes may be caused by the policy of grain for green and urban expansion. This study provides a strong theoretical basis for policy-making of environmental protection and management in Xiangxi Region of Hunan Province in China.

1.Introduction

Land Use/Cover Change(LUCC) is a key factor to impact on landscape structure, function and dynamics^[1]. It also has significant impact on global climate change and sustainable development^[2,3]. Pattern and process refer to the spatial relationship between different landscape or geographical units and the process of response to this kind of relation. Continuous change of landscape pattern may cause alteration in erosion, water and nutrients circulation^[4]. Recent researches devote into define and quantify the spatial-temporal change of landscape structure, landscape fragmentation and heterogeneity. Spatial technology tools such as geographic information systems (GIS) and remote sensing(RS) have successfully helped ecologists to conduct these thoughts^[5-7]. Studies of landscape ecology on urban and something related are more complete^[8-10]. However, mountainous regions usually have high value of ecosystem service. And terrain closely relates to landscape pattern.

Xiangxi Region has high quality of natural resources, world natural heritage sites and historical and cultural cities. But the development of social-economic is relatively backward. The conflict between environmental conservation and economic development tends to be serious. It is significant to find out the reasonable use of different landscape types. In this study, Xiangxi Region was selected as a case study area to conduct appropriate analysis for studying landscape structural changes. Then, digital image processing techniques was used to obtain landscape classified maps in the years of 1990, 1995, 2000, 2005, 2010 and 2015. Based on ARCGIS and FRAGSTATS, five landscape pattern indices in landscape level and four indices in class level were chosen and calculated. Topography is complicated in this region. So terrain factors have been considered into the study. These results could provide a



strong theoretical support for better eco-environmental conversation and sustainable development in Xiangxi Region.

2. Study area and method

2.1. Study area

Xiangxi Region locates in the west of Hunan Province, including Shaoyang, Zhangjiajie, Huaihua, Loudi city and Xiangxi Tujia-Miao Autonomous Prefecture with total area of 8.169 km²(fig.2). It is the central region of four province boarder, between 108°47'—112°57' longitude, and 25°58'—29°48' latitude. The concept of Xiangxi was firstly proposed during Western Development. Xiangxi Region, from the elevation 50m to 1903m, has Wuling and Xuefeng Mountains and it's surrounded by Yungui Plateau. It belongs to the subtropical monsoon humid climate with typical continental characteristics. The annual average temperature is about 17~18 °C, and the annual precipitation is 1100~1600 mm. By the end of 2015, the resident population was 20.19 million, taking up 29.77% of Hunan Province. Gross domestic product in Xiangxi Region was 48.97 billion, taking up 16.09% of Hunan Province^[11]. This region is a muti-ethnic region in the province and it's the main area of 20 concentrated poverty-stricken counties in the western part of Hunan Province. The ecological development and environmental conservation are of great importance .

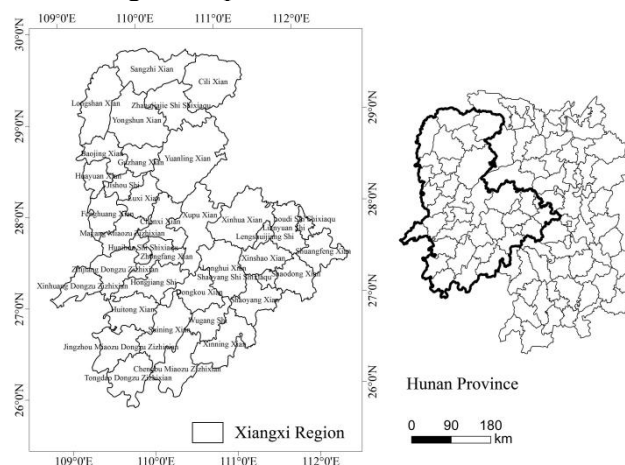


Fig. 1. Location and zoning of Xiangxi Region

2.2 Methodology

The remote sensing imagery data of year 1990, 1995, 2000, 2005, 2010 and 2015 with 1:250000 topographic map, soil and plant thematic map are used to divide landscape types into 7 categories: farmland, forestland, grassland, water, building land, unused land and wetland (fig.2). The landscape types of six periods were overlapped and the matrix of LUCC was obtained by using the spatial data overlay analysis. Furthermore, the spatial analysis module of ARCGIS and FRAGSTATS software were used to calculate the landscape pattern metrics in class level and landscape level.

DEM data was used to extract elevation and slope data in Xiangxi Region. And we used formula below to calculate topographic index, followed by gradient division(Tab.1). Then this study analyzed the dynamics of landscape pattern along different gradients.

$$T = \ln \left[\left(\frac{E}{E_0} + 1 \right) \times \left(\frac{S}{S_0} + 1 \right) \right] \quad (1)$$

Table 1. The gradients of topographic index setting in Xiangxi Region.

Level	Gradient range
1	0-0.291
2	0.291-0.515
3	0.515-0.702
4	0.702-1.104
5	1.104-2.313

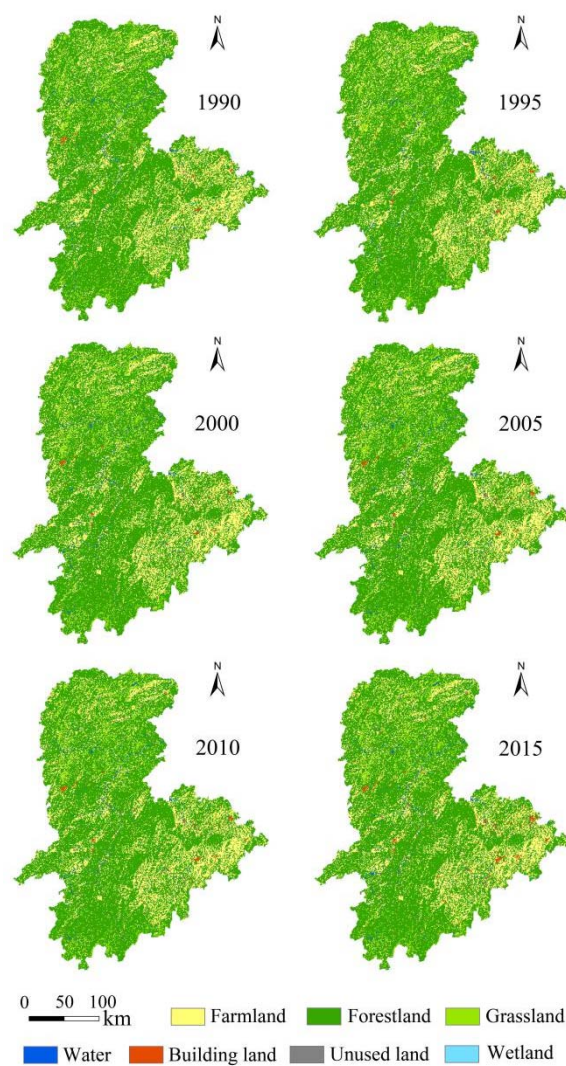


Fig. 2. Landscape types in Xiangxi Region from 1990 to 2015

3. Results and analyses

3.1 Change of characteristics of landscape type in Xiangxi Region

For 25 years from 1990 to 2015, farmland, forestland, grassland, unused land and wetland generally decreased in Xiangxi Region while water and building land increased. Forestland, as the largest landscape type in the study area, has reduced 23300 ha in 20 years from 1995 to 2015. Farmland, the second large landscape type, has decreased 50200 ha in 25 years, with 0.10% rate of decrease.

Wetland increased from 2005. Building land occupied 0.75% of entire area in 1990, but 1.32% in 2015, with 45300 ha increasing. Building land had the largest increasing rate up to 3.00%.

Xiangxi Region has been practicing the policy of grain for green and afterwards extended to convert farmland to wetland. The results possibly showed that returning farmland and increasing wetland have been completed better. Forestland occupied the most area in Xiangxi Region and the change of it is slight. However, urban expansion here is serious for the increasing rate of building land is much larger than other types. The area of water increased for flood control and water conservancy regulation use. In general, land resources have not been protected well in study region yet, because the natural types of landscape are on decline while building land is on opposite. It should take more actions to guarantee the sustainable use of land and healthier development of Xiangxi Region.

3.2 Landscape pattern dynamics of Xiangxi Region

3.2.1 Dynamics in landscape level

The data of increasing patch numbers (6024 in 1990 and 6274 in 2015) and patch density (0.072 in 1990 and 0.075 in 2015) showed that the landscape patches have become considerably fragmented during 25 years (Tab.2). The fractal dimension index is used to demonstrate the characteristics of landscape spatial distribution attributes. It can reveal the distribution of landscape patches and can subsequently reflect the aggregation or separation of those patches. The decrease of fractal index showed that landscape patch shape tended to simplify and the arrangement tended to be more closely and orderly. Shannon diversity index increased from 0.844 to 0.863 and contagion index decreased from 57.888 to 56.998. It means that landscape diversity increased in 25 years and so did the fragmentation in Xiangxi Region.

In summary, landscape heterogeneity, fragmentation and landscape diversity increased in the study area. Landscape patches tended to be rules and simplified.

Table 2. Change of landscape pattern indices in landscape level in Xiangxi Region from 1990 to 2015.

Year	NP	PD	FRAC_MN	SHDI	CONTAG
1990	6024	0.072	1.02	0.844	57.888
1995	5877	0.071	1.02	0.839	58.185
2000	6001	0.072	1.02	0.843	57.954
2005	6022	0.072	1.02	0.846	57.815
2010	6081	0.073	1.019	0.85	57.629
2015	6274	0.075	1.019	0.863	56.998

NP: Patch number; PD: Patch density; FRAC_MN: Mean fractal dimension; SHDI: Shannon diversity index; CONTAG: Contagion index.

3.2.2 Dynamics in class level

Comparing year 1990 and 2015, patch number of farmland and unused land were increased. It indicated that the fragmentation of these two landscape types increased. And interspersions juxtaposition index (IJI) of these two types were both increased, showing that the distribution of farmland and unused land have trend to be segmented. The declining of the shape index of farmland these years indicated that farmland patches tended to simplify and it may result from the governors' management and planning. The shape index of building land increased so its patches tended to be more complicated. Xiangxi Region is a mountainous region, so local people have to construct buildings along the mountains there and it possibly caused the increase of building land shape index.

The patch number and patch density of forestland, grassland, water and wetland decreased in study period. It closely related with the area change. Interspersions juxtaposition index of forestland, grassland and water were increased. Combined with patch number, these three landscape types tended to be segmented and fragmented. The shape index of forestland and grassland declined showing the

simplification of these two types' patches. Although landscape patches tended to be simplified in the entire study area, individually, the shape index of water and wetland increased, so it meant their patches became more complex.

Table 3. Change of landscape pattern indices in class level in Xiangxi Region from 1990 to 2015.

Landscape type	Year	NP	PD	SHAPE_MN	IJI
Farmland	1990	3199	0.0384	1.2398	23.2240
	1995	3163	0.0380	1.2350	22.9328
	2000	3249	0.0390	1.2395	23.2800
	2005	3254	0.0391	1.2382	23.5459
	2010	3256	0.0391	1.2385	23.9631
	2015	3281	0.0394	1.2367	25.3355
Forestland	1990	293	0.0035	1.3980	39.7946
	1995	301	0.0036	1.3569	39.6529
	2000	281	0.0034	1.3971	39.9087
	2005	282	0.0034	1.3947	40.3245
	2010	280	0.0034	1.3977	40.8746
	2015	290	0.0035	1.3865	42.7878
Grassland	1990	1461	0.0175	1.1776	31.6948
	1995	1454	0.0174	1.1769	31.9331
	2000	1450	0.0174	1.1704	32.7968
	2005	1445	0.0173	1.1701	32.9847
	2010	1449	0.0174	1.1688	33.1844
	2015	1452	0.0174	1.1660	33.6164
Water	1990	565	0.0068	1.0408	52.2463
	1995	474	0.0057	1.0694	51.7189
	2000	551	0.0066	1.0631	50.8962
	2005	555	0.0067	1.0684	50.9219
	2010	557	0.0067	1.0653	51.8777
	2015	549	0.0066	1.0654	52.8885
Building land	1990	428	0.0051	1.0374	50.8702
	1995	418	0.0050	1.0296	51.5437
	2000	411	0.0049	1.0380	51.8864
	2005	426	0.0051	1.0403	52.1176
	2010	469	0.0056	1.0407	52.5354
	2015	630	0.0076	1.0495	51.5775
Unused land	1990	6	0.0001	1.1389	47.3053
	1995	9	0.0001	1.0000	50.1783
	2000	6	0.0001	1.0667	50.2424
	2005	6	0.0001	1.0667	50.2424
	2010	6	0.0001	1.0667	50.2424
	2015	7	0.0001	1.0357	51.0686
Wetland	1990	72	0.0009	1.0116	69.4625
	1995	58	0.0007	1.0259	63.6678
	2000	53	0.0006	1.0126	65.9842
	2005	54	0.0006	1.0123	62.4050
	2010	64	0.0008	1.0156	61.9228
	2015	65	0.0008	1.0205	62.9199

NP: Patch number; PD: Patch density; SHAPE_MN: Mean shape index; IJI: Interspersion juxtaposition index.

3.3 Change of landscape pattern along topographic index gradient in Xiangxi Region

On average, patch number and patch density in Xiangxi Region reached a peak on the second gradient of topographic index. And these two indices decreased ranging from level 2 to level 5. This indicated that the most serious fragmentation occurred on second and third gradient, and the higher topographic index, the slighter fragmentation. Fractal dimension increased from level 1 to level 4 but fell on level 5, approximately showing that more landscape patches with complicated shape spread on higher topographic index gradient. This may result from the management of governors' on lower gradients. Shannon diversity index declined as gradient up which meant the landscape diversity decreased with rising gradient. The increase of contagion index as gradient up also showed that fragmentation and segmentation were more serious on lower topographic index gradient.

During the study period, patch number and patch density increased on level 1 and level 3 while decreased on level 2, level 4 and level 5 over time. It may showed that on level 1 and 3, landscape tended to be more fragmented and on other gradient levels connectivity tended to be better. Fractal dimension increased on level 2 and 4, decreased on level 3, increased firstly and then decreased on level 1 and 5. This indicated that the landscape shape on level 2 and 4 tended to be more complicated and irregular. However, diversity index on all gradient levels were increased with time, showing the increasing of landscape diversity on every topographic index gradients. Contagion index on level 1, level 4 and level 5 declined and on level 2 and 3 increased over time.

In summary, the more serious fragmentation commonly occurred on lower topographic index gradient. And the landscape on the first gradient of topographic index became more fragmented and it became more connected on second gradient of topographic index.

Table 4. Change of landscape pattern indices in landscape level along topographic index gradient in Xiangxi Region from 1990 to 2015.

Lev-el	Year	NP	PD	FRAC_M N	SHDI	CONTAG
1	1990	2382	0.1433	1.0142	0.9644	51.4911
	1995	2368	0.1425	1.0145	0.9724	46.9449
	2000	2407	0.1449	1.0143	0.9732	50.9785
	2005	2419	0.1457	1.0142	0.9826	50.5316
	2010	2432	0.1464	1.0142	0.9914	50.0528
	2015	2474	0.149	1.0141	1.0269	48.1901
2	1990	3260	0.1956	1.0149	0.8515	53.6424
	1995	3249	0.1948	1.0146	0.8373	54.5080
	2000	3198	0.1922	1.0150	0.8412	57.9480
	2005	3203	0.1925	1.0150	0.8432	57.7898
	2010	3210	0.1929	1.0150	0.8479	57.4752
	2015	3224	0.1937	1.0150	0.8579	56.8774
3	1990	3093	0.1861	1.0159	0.7439	59.9020
	1995	3143	0.1895	1.0153	0.7530	59.4517
	2000	3131	0.1889	1.0155	0.7620	62.1914
	2005	3127	0.1887	1.0156	0.7635	62.1467
	2010	3124	0.1885	1.0156	0.7647	62.1151
	2015	3142	0.1896	1.0155	0.7738	61.5661
4	1990	3088	0.1864	1.0166	0.7678	61.6577
	1995	3029	0.1830	1.0165	0.7489	62.6919
	2000	3008	0.1821	1.0174	0.7595	62.2066

5	2005	3009	0.1822	1.0174	0.7609	62.1412
	2010	3012	0.1824	1.0174	0.7615	62.1020
	2015	3021	0.1829	1.0173	0.7687	61.7057
	1990	1785	0.1081	1.0157	0.6865	65.6114
	1995	1760	0.1066	1.0170	0.6837	65.7924
	2000	1774	0.1077	1.0165	0.6921	62.5582
	2005	1770	0.1074	1.0165	0.6923	62.5607
	2010	1770	0.1074	1.0165	0.6928	62.5378
	2015	1775	0.1077	1.0164	0.6982	62.2184

NP: Patch number; PD: Patch density; FRAC_MN: Mean fractal dimension; SHDI: Shannon diversity index; CONTAG: Contagion index.

4. Conclusion

Different landscape types have different dynamics change from 1990 to 2015. The area of farmland, forestland, grassland, unused land and wetland has decreased while the water and building land has increased. This change possibly caused by the conduction of grain for green policy. And it is noteworthy that urban expansion in Xiangxi Region is serious for building land increased more fast than that of other areas.

The fragmentation in Xiangxi Region has trend to be serious but the shape of patches were more simple under human disturbance and management possibly. Individually, the fragmentation of farmland, building land and unused land was more serious. The patch shape of building land, water and wetland was more complicated.

The fragmentation in Xiangxi Region was less serious as topographic index increased. But the shape of patches was simpler on lower gradients. On temporal change, landscape on the first topographic index gradient was more fragmented and landscape on the second gradient was more connected.

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