地理学报(英文版) 2003年第13卷第3期

The spatial-temporal changes of the land use/cover in the Dongting Lake area during the last decade

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The research on the land use/cover change is one of the frontiers and the hot spots in the global change research. Based on the Chinese resource and environment spatial-temporal database, and using the Landsat TM and ETM data of 1990 and 2000 respectively, we analyzed the spatial-temporal characteristics of land use/cover changes in the Dongting Lake area during the last decade. The result shows that during the last ten years there were three land-use types that had changed remarkably. The cultivated land decreased by 0.57% of the total cultivated land. The built-up land and water area expanded, with an increase of 8.97% and 0.43% respectively. The conversion between land use types mostly happened among these three land-use types, especially frequently between cultivated land and water area. The land-use change speed of land-use type is different. Three cities experienced the greatest degree of land-use change among all the administrative districts, which means that the land use in these cities changed much quickly. The following changed area was the west and south of the Dongting Lake area. The slowest changed area is the north and east area.

The spatial-temporal changes of the land use/cover in the Dongting Lake area during the last decade LI Rendong1,2, LIU Jiyuan2, ZHUANG Dafang2, WANG Hongzhi3 (1. Inst. of Geodesy and Geophysics, CAS, Wuhan 430077, China; 2. Inst. of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China; 3. Faculty of Life Science, Hubei University, Wuhan 430062, China) 1 Introduction Changes of land cover and land use are of vital importance among human alteration of the Earth´s land surface (Eric F Lambin et al., 2001). Therefore the land use and land cover change study is an essential part of the Earth´s land surface science and also one of the frontiers and hot spots of the global change study (Li, 1996; Liu et al., 2000; Cai, 2001). Recently, supported by remote sensing technique and the completely spatial and temporal series data, the research on spatial characteristics and modern process of the Earth´s land surface has entered a new stage marked with quantity and parameter (Liu et al., 2000; Read et al., 2002; Liu et al., 2002; Zhang et al., 2002). With the rapid development of remote sensing and GIS technologies, mapping and monitoring land use and land cover developed rapidly and have become more systematic, objective, rapid and correct (Liu, 1996; D S Alves, 2002). Dongting Lake, located on the southern bank of the middle Yangtze River, is the second largest fresh water lake in China. The rapid environmental changes and the varied relation among the lake, river and inhabitants made the area one of the typical cases of the regional study of the land use and land cover change in China. Before the mid-1980s many researchers conducted a lot of researches on reclamation, the deposition of silt, land use and the flood disaster in the drainage area. After the mid-1980s, the areal changes of land use and land cover needed to be researched further. 2 Study area The Dongting Lake drains an area of 28,737 km2, of which 22,875 km2 are in Hunan province, and 5,862 km2 in Hubei province (Figure 1). This area is a subsided district due to the Neotectonics, and the average subsiding rate is about 3.7 mm annually based on the analysis of the available geological drilling data. A measurement of earth level showed that the average subsiding rate of the area was about 10 mm annually from 1925 to 1953. The Dongting Lake holds huge amount of water and silt coming from the Xiangjiang, Zishui, Yuanjiang and Lishui rivers, and three diversions of Changjiang river, Songzi, Hudu and Ouchi rivers, then the lake water flows out into the Changjiang River at Chenglingji. Because of the long-term natural deposition and reclamation, the lake area has become much smaller than in history, and as a result the lake body was divided into three parts, i.e., the east, the south and the west Dongting Lake, by groups of small lakes, ditches, beaches, small islands, flood channels and hydrophytes (Li, 1992). As a big lacustrine and fluvial plain, the lake area is formed partly by the reclamation. According t o analysis, of the 18.3×104 ha of cultivated land reclaimed from the main lake during 1949 to 1979, about half was reclaimed from the inner lake body (Bian et al., 1985). Besides, the formation of the lake area is also controlled by the deposition. According to the measurement conducted from 1974 to 1998, the average annual sediment deposition accepted by the Dongting Lake was 14.73×108 m3 and the average rise of the lake bed was 0.43 m every year (Gao et al., 2001). As known to all, the lower Jingjiang river, a part of the middle Changjiang river, has been cut three times since 1949, one of two artificial channel cutoffs at Zhongzhouzi in 1967, the other one at Shangchewan in 1969 and one natural straightening at Shatanzi in 1972. As a result, the tortuosity of the channel decreased from 2.83 to 1.93 and the length reduced 78 km. The cut-off of the lower Jingjiang river changed the relationship between Jingjiang river and the Dongting Lake. Generally speaking, the amount of the deposition of silt reduced rapidly in the 1970s even though a little increase in the 1980s (Zhang, 1996). Since the 1980s the shrinkage of the three mouths seemly has been curbed to a certain extent. 3 Data and methods 3.1 Data In order to describe the modern evolution process of the Earth´s surface and further to predict the trend of land use change, the databank with spatial and temporal characteristics needs to be built completely (Liu et al., 2000). The spatial data of land use change in our paper came from the national resource and environment database. Moreover, Landsat TM or ETM data, which were captured in 1990 and 2000 respectively, were used for extracting the land use change information while topographic map, regional thematic research data and maps were consulted. 3.2 Methods There are three methods to monitor the change of the land use and land cover by using remote sensing and GIS. The first is the automatic classification based on the spectrum characteristic of image pixel. This method is applied well in the area where the land use has big unity and big difference of spectral reflectance among different land use types. But when the land use of the area is complex, the precision of this method cannot meet the requirement of research work. The second is an improved automatic classification based on the knowledge system of geo-science. Compared with the first method, the advantage of this method is the use of multi-dimensional spatial information including remote sensed information and other non-remote sensed information, and the classification precision improved. The third is the method based on the integration of remote sensing and GIS. Supported by the knowledge of specialists and the data of fieldwork, the interpretation of image, after the image is geometrically corrected, is conducted on the computer. By this method, the demand on the consistency of radiation of different temporal images is not strict, and the result of the work does not need to be digitalized anymore before being put into database. Therefore the classification precision can be improved greatly. So the third method was adopted, and some steps were conducted in our study. The first step was to classify the land use types and build up the land use database. A two-level classification system was applied. There are six types in the first-level, which were cultivated land, woodland, grassland, water area, built-up area and unused land. In the second level of the classification, there are 19 types. For example, the cultivated land is divided into paddy field and dry land. Detailed works included the establishment of the land use classification system, of the marks for land use interpretation of image, the image interpretation, and the building up of the land use database. The second step is to detect the change of land use and to establish the dynamic database. During this step, the first is to register the images geometrically by referring to China´s resources and environment database, then to overlay the basic maps of land-use on the images, and still then to detect the land use change and to draw out the change patches, and finally to detect the land use changes and to give an identified number to every patches of the changes. Every identified number was coded with 6 figures, of which the former three figures represent the basic land use condition, and the latter three identify the land use change. The last step is to build up the database on land use dynamic change. 4 The spatial-temporal characteristics of the land use and land cover change 4.1 The change and the conversion of land use/cover The research results indicated that areas of all the six first-level land use types changed, in which, areas of two land use types, farmland and woodland, decreased, and of the other four types, water area, grassland, built-up area and unused land, increased from 1990 to 2000(Figure 2 and Table 1). Among the land use types with areas decreased, the cultivated land decreased most, the amount of the area decreased was up to 8,984 ha, the proportion to the total area declined from 55.51% to 55.19%, and the decreased rate was 0.57% of the total farmland during the 10 years. In the sub-classification of cultivated land, the area of paddy field decreased 5,826 ha, and the dry land area reduced by nearly 1/3 of the paddy field (Figure 3). The area of woodland decreased 925 ha. In detail, the areas of forest and shrub increased a little, but the total increased area was far less than the total decreased area of sparse wood and other woodland. Among the land use types with areas increased, the built-up area increased most, up to 7,473 ha, and the proportion increased by 0.26%. Compared to the late 1980s, its increased rate was 8.97%. The urban land and industrial land expanded more than 3,800 ha and 2,800 ha respectively. Rural residential land increased a little, and part of the reason was that the area of some pitches are smaller than the minimum size and therefore cannot be extracted and counted.Another land-use type who

se area increased remarkably was the water area, with an increase of 1,586 ha, about 0.06% of the total area, and the increased rate of 0.43%. In more detail, there increased 2,600 ha area of beaches along lakes and rivers, and so did some lakes area. But the area of reservoirs, fishponds, and other ponds decreased 779 ha. The increase of the area of grass and unused land was very small, only 642 ha and 208 ha respectively. Through the study of land use and land cover change, the conversion of land use and land cover can be probed into. About 94% of the decreased cultivated lands were converted to water and built-up areas (Table 2). Though there was 3,658 ha of water area being converted to cultivated land, and made up the loss of the cultivated land partly, the main transforming directions were from paddy field or dry land to lake, fishpond and residential land. The area of forest decreased a little, less than 1,000 ha during the observed time period. It was mainly converted to built-up land, and the rest was largely transformed to farmland. In detail, there were 568 ha of being converted to industrial and mining land, and 312 ha to urban land. Among the land use types with area increased, the area of water body increased most, which was mainly changed from paddy field. During the period, though there were 2,388 ha of reservoir and fishpond turning to paddy field, the amount of the reverse change was 4,094 ha. So, there were 1,706 ha of paddy field turning to reservoir and fishpond totally, mostly to fishpond. Besides, the rest of the increased area of water body came from grassland and unused land, hardly from forest. So it also shows that the reclamation was curbed effectively in the lake area. The expansion of every kind of built-up land was very obvious, too. The increased area came from different land. Of which, 74% of increased area came from cultivated land, 21% from forest, and 67% of cultivated land loss was from paddy field. 4.2 The dynamic degree of land use/cover The dynamic degree model of land use is one of the best indexes to describe the rate and the spatial difference of land use and land cover. Liu Jiyuan defined the dynamic degree model of land use as follows (Liu et al., 2000): s = (?驻si-jsi)*(1/t)*100% (i, j = 1, 2, … n) (1) where si is the total area of the land use type ´i´ at the beginning of monitoring, △si-j is the overall area of land use type ´i´ changed to ´j´ type from the beginning to the end of the monitoring period, t is the period of the years from beginning to the end of monitoring, and s is the land use change rate among the period ´t´, which is the land use change dynamic degree. The results of dynamic degree calculated for the first-level land use types in the study area indicated that, from 1990 to 2000, the values of dynamic degree of grassland and unused land were obviously greater than other land use types (Table 3). The causes of great dynamic degree of grassland and unused land were that the total areas of grassland and unused land were relatively less than that of other types, and furthermore they were influenced much by water levels that lead to a frequent change of grassland and unused land seasonally. No built-up land was changed to others, so the degree of it is zero. The value of the change rate of water body was similar to that of cultivated land. With 0.225 and 0.221 of the degree, it indicated that water area and farmland changed rapidly while woodland is only 0.043, which means that it changed slowly, even though its area is remarkably smaller than that of the former two types. 4.3 The regional differentiation of land use/cover In order to reveal the regional differentiation of land use and land cover change, the degree for each county was calculated. The dynamic degree of land use/cover reveals that Shishou, Yueyang and Jinshi cities have the high dynamic degree of more than 20 from 1990 to 2000 (Figure 4), suggesting greatest changes of land use/cover in all counties. All these three cities, located in the south bank of Jingjiang River or on the side of a flood way of Jingjiang River, have favorable economic conditions and more population. Obviously it was the social and economic forces that drove the land use changes in these cities. Gongan county with higher dynamic degree of 16.97 is located in the west of the Dongting Lake area, which indicated that the west of the lake area is still strongly influenced by human activity. The land use changed rate was the smallest in Yueyang, Huarong, Miluo, Xiangyin and Nanxian counties, which were distributed near the east and southeast of the Dongting Lake area. The amounts of dynamic degree for all these counties are less than 5. Due to the slow growth of economy and population in the 5 counties and to the lower sediment deposition in the east and southeast of the Dongting Lake area, the land use/cover changes in these counties are not as great as in other areas. 5 Conclusions In this paper, the database of the land use and land cover dynamic change from 1990 to 2000 was built up rapidly through the integration of remote sensing and GIS technique. The result shows that changes of farmland, water bodies and built-up land were frequent. The cultivated land area decreased 0.5%, built-up land increased 8.9%, and water bodies increased 0.43%. The reclamation was curbed effectively in the lake area. Changes of land use and land cover mainly happened among those three land types. Especially, with the highest dynamic degree, Shishou, Yueyang and Jinshi cities were the area where the land use changed rapidly. All of them have economic conditions and more are populous. The slowest changed area existed in the counties near to the east and southeast of the lake area.

关键词： land use/cover change; remote sensing; Dongting Lake area