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Landuse/landcover changes in Zhangye oasis of Hexi Corridor

MENG Jijun, WU Xiuqin, LI Zhengguo
(Department of Urban and Environmental Science, Peking University, Laboratory of Analysis and Simulation of Earth Surface Processes, the Ministry of Education, Beijing 100871, China)

Abstract: Taking two false color composite Landsat 5 TM (Thematic Mapper) images of band 4,3,2 taken in 1995 and 2000 as data resources, this paper carried out study on LUCC of Zhangye oasis in recent five years by interpretation according to land resources classification system of 1:100,000 Resources and Environmental Database of the Chinese Academy of Sciences. The results show that great changes have taken place in landuse/landcover in Zhangye oasis since 1995: (1) Changes of landuse structure show that cropland and land for urban construction and built-up area increased, on the contrary, water area and grassland decreased. These changes reflect the deterioration of eco-environment and the acceleration of urbanization, and also indicate the problems existing in the arrangement of water and land resources between the upper and lower reaches of the Heihe River. (2) Regional differences of landuse/landcover are evident, characterized by following aspects: in Sunan County located in Qilian Mountain area, unused land and grassland decreased, but cropland and land for urban construction and built-up area increased. In Minle and Shandan counties located in foothills, unused land, water area and cropland decreased, but grassland and land for urban construction and built-up area increased. In Zhangye City, Linze County and Gaotai County located in plain area of the middle reaches of the Heihe River, unused land, water area and grassland decreased, while woodland, cropland and land for urban construction and built-up area increased.
Key words: landuse/landcover changes (LUCC); Zhangye oasis; Hexi Corridor
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1 Introduction

Human activities, especially landuse, have changed physical geographical environment greatly, the direct result of which is the changes of landcover (Turner II *et al.*, 1990). At present, many problems facing people are related with landuse/landcover changes (LUCC). Study on LUCC enjoys especially important meanings in studies on global environmental changes. First, it provides scenario for global and regional modes of climatic changes and for modes of terrestrial ecosystems. Second, it contributes to explaining interior mechanism of interactivities of man-land system. So study on LUCC has been an international front of integrated research of geography (Cai, 2001). Hexi Corridor refers to the area west of the Yellow River (also named Hexi Region). In geographical articles of foreign countries, people also call it Gansu Corridor. In terms of administration, Hexi Corridor includes three prefectures (Wuwei, Zhangye and Jiuquan) and two cities (Jinchang and Jiayuguan). It extends 1,100 km from east to west and covers an area of 276,000 km^2 or more than 60% of the Gansu Provincial total and has a population of 4.68 million. In natural landscape, it consists of three parts. In the south, it is the high Qilian Mountains, constituting important waterhead area and water conservation forest of Hexi Corridor. In the north, it is low mountains and residual hills having been denuded for a long time and is characterized by desert and gobi. In the middle, plain is the main landscape, which is divided into three water systems (Shiyang, Heihe and Shule rivers) by Dahuang and Dahei mountains. This region witnessed development of numerous oases, big or small and has

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Author: Meng Jijun (1971-), Ph.D., specialized in study on integrated physical geography and LUCC.
E-mail: jijunm@urban.pku.edu.cn

become a core region for economic development of the corridor. On the whole, the natural pattern of Hexi Corridor is uneven and ecosystems are very fragile, especially the deficient water resources have limited the economic development and resource utilization in this region (Meng, 1998; Meng *et al.*, 1999). At present, desert area is 50,300 km^2, occupying 18.3% of the whole land area (Leng *et al.*, 2000). With the implementation of development strategy of western regions in our China, Hexi Corridor will be a link and support to the development of western regions. The target of "Remaking Hexi Corridor" will come true then. At the same time, both the adjustment of industrial structures on a large scale and the improvement of eco-environment will be tasks facing Hexi Corridor. Therefore studies on LUCC are in urgent need to seek an approach to sustainable development and to make strategy of ecological security to fulfil sustainable development of Hexi Corridor.

2 Study area and data

2.1 Study area

In this paper, we took Zhangye oasis as a study area, which is located in the central part of Hexi Corridor (Figure 1). In geographical units, it includes all the oases distributed along Heihe River system (from Yingluo valley to Zhengyi valley). In administration, it consists of Zhangye City, Linze, Gaotai, Minle, Shandan and Sunan counties (Figure 1). This region has been enjoying good fames of "South of the lower reaches of the Yangtze River on the Great Wall" and "Golden Zhangye" since ancient times. It covers a total area of 4.214 million ha, occupying 9.2% of the provincial total. This region, with a population of 1.252 million (Gansu Statistical Bureau, 2000), has been developing from early times with relative speedy economic development and has great potential for future development. With Gross National Product being 6.41 billion yuan in 2000, it is both culturally and economically active in Hexi. The local people's life has been proceeded from being adequatly fed and clad to being fairly well off.

2.2 Data

Data adopted in this paper were composed of spatial data and statistical data of national economy and social development, among which spatial data came from the interpretation of composite Landsat 5 images of bands 4, 3 and 2 (RGB) in 1995 and 2000 according to landuse classification system (at scale of 100,000) of environmental database of the Chinese Academy of Sciences. A three level classification system was adopted according to management features of land resource, landuse and landcover. Leve I consists of 6 landuse types, namely cropland, forestland, grassland, water area, urban or built up and unused land in light with attributes of land resources and land utilization. Level II, contains 25 landuse types mainly in light with natural attributes of land. Level III is subdivided into 8 categories according to geomorphic types of land. The data are stored as coverages in unit of county under the support of Chinese edition of ARC/INFO7.1.

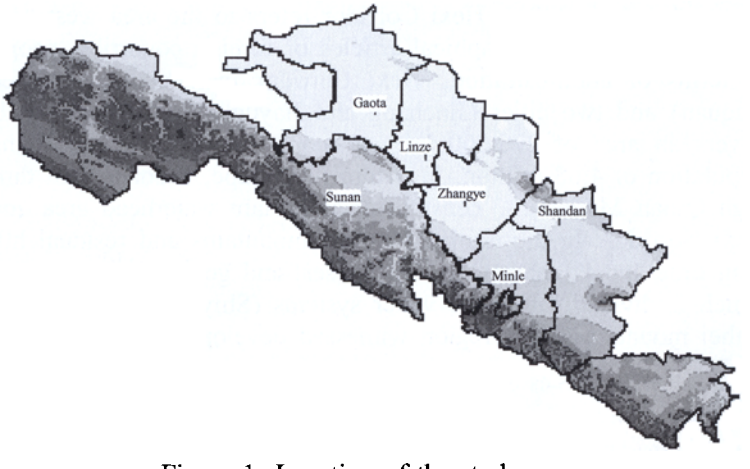

Figure 1 Location of the study area

3 Method

3.1 Data processing

This paper mainly analyzed the spatial distribution of different landuse types from a macroscopic viewpoint.

So it is unnecessary to divide landuse types in detail. Six types at level I were obtained from images of 1995 and 2000 according to the need of research, which was mentioned above, i.e., cropland, forestland, grassland, water area, urban or built-up area and unused land. Then by Mapjoin demand in ARC/INFO, coverages of each county were joined into an integrated one. With the help of Arcview and Excel, information of changes of landuse was obtained.

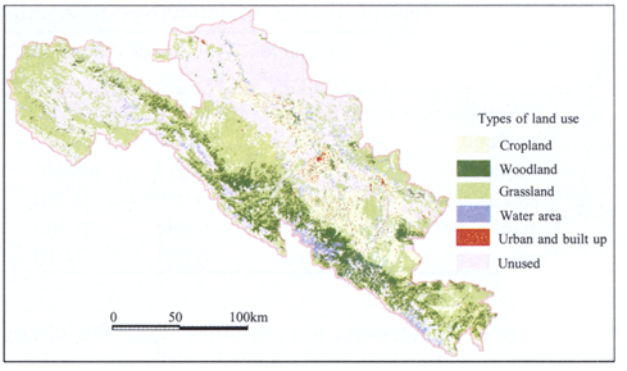

Figure 2 Landuse pattern in 1995

3.2 Extraction of LUCC

Landuse patterns of 1995 and 2000 are shown in Figures 2 and 3.

3.2.1 General tendency of LUCC We got general spatial distribution of LUCC (Figure 4) between 1995 and 2000 by overlaying coverage of 1995 with that of 2000. The changes of each landuse type are shown in Figure 5.

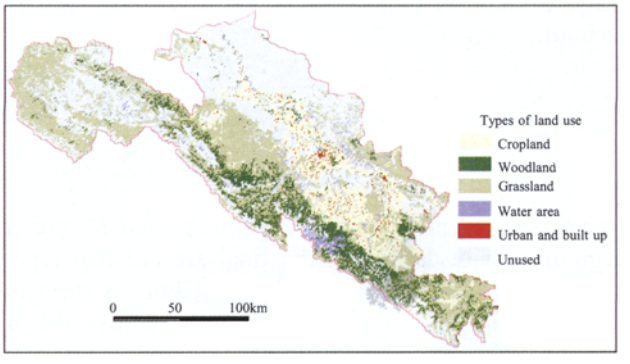

Figure 3 Landuse pattern in 2000

3.2.2 Transition matrix According to mathematic theory, such a graphical algebraic equation can be used for any two landuse maps of different times (A_k and A_{k+1}):

$$C_{ij} = A_{ij}^{k} \times 10 + A_{ij}^{k+1} \text{ (when the number of landuse type is less than 10)} \quad (1)$$

Then map (C_{ij}) of landuse changes between time k and time $k+1$ was obtained, which showed the changes in landuse types and their distributions directly. We went a further step to get the transition matrix of interchange of different landuse types (Tables 1 and 2).

3.2.3 Relative change degree of LUCC Relative change rate of a single landuse type can be used to show the regional differences of the amount changes of landuse (Zhu Huiyi *et al.*, 2001). When it is greater than 1, the change amplitude of one landuse type is greater than the change of this type in the

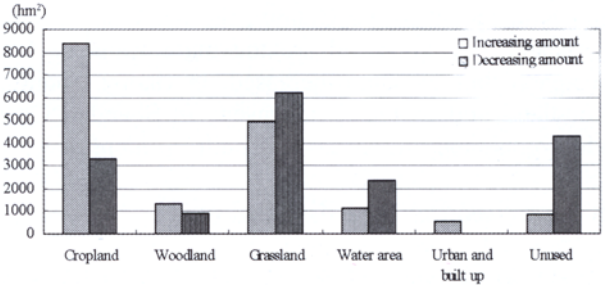

Figure 4 Land cover type changes from 1995 to 2000

Table 1 Transition matrix of landuse in Zhangye oasis (landuse in 1995 to others)

1995	Cropland	Woodland	Grassland	Water area	Urban and Built up	Unused
				2000		
Cropland	99.029	0.115	0.654	0.104	0.099	0.000
Woodland	0.077	99.857	0.043	0.016	0.003	0.003
Grassland	0.272	0.037	99.660	0.016	0.005	0.010
Water area	1.219	0.180	0.536	97.975	0.010	0.081
Urban and built up	0.000	0.000	0.000	0.000	100.000	0.000
Unused	0.153	0.009	0.100	0.013	0.004	99.758

Table 2 Transition matrix of landcover in Zhangye oasis (landuse in 2000 from others)

2000	Cropland	Woodland	Grassland	Water area	Urban and Built up	Unused
				1995		
Cropland	97.853	0.156	1.067	0.325	0.000	0.600
Woodland	0.089	99.710	0.127	0.043	0.000	0.031
Grassland	0.150	0.013	99.736	0.037	0.000	0.064
Water area	0.402	0.080	0.270	99.019	0.000	0.229
Urban and built up	1.094	0.041	0.269	0.034	98.344	0.217
Unused	0.000	0.001	0.010	0.005	0.000	99.983

whole region. Otherwise it is smaller than the change of the whole region. But it is not good for presenting vertical relation of different types of landuse. It is also not good for the comparison of landuse changes in each city or county. So in this paper, the relative degree of landuse changes (R_i) is only used to show the regional differences of changes of landuse amount.

$$R_i = \frac{\dfrac{|K_{bi} - K_{ai}|}{K_{ai}}}{\dfrac{|C_b - C_a|}{C_a}} \times \frac{|K_{bi} - K_{ai}|}{\sum_{i=1}^{5} |K_{bi} - K_{ai}|} \tag{2}$$

where i represents a certain region, K_{ai} and K_{bi} are the original area of one landuse type at the beginning of research and the final area of that type in the end individually in i region. C_a and C_b mean just the same as K_{ai} and K_{bi}, but for the whole region. R_i is the relative change degree County. For grassland, Minle County enjoys the highest change degree (2.34) while Sunan County is on the contrary (0.09). For water area, it is the highest (2.20) in Zhangye City and lowest (0.19) in Gaotai County. For urban and built up, the highest degree (1.81) is in Minle, and the lowest (0.04) is in Linze. For unused land, the relative change degree is the highest (4.90) in Minle, and the lowest (0.29) in Gaotai.

4.2.2 Differences of LUCC of each city or county In Zhangye City, the features of LUCC are: decrease in woodland and unused land and increase in cropland. Sunan County is characterized by a decrease in unused land and grassland and an increase in cropland and urban and built up. In Minle County, the decrease in unused land and water area and the increase in grassland and woodland are the main features. In Leze County, water area and unused land decreased but cropland increased. In Gaotai County, unused land and water area decreased and woodland and cropland increased. In Shandan County, water area and unused land decreased while grassland and urban and built up increased.

5 Conclusions and discussion

(1) In Zhangye oasis, located in the middle of Hexi Corridor, cropland and urban and built-up area increased while water area and grassland decreased between 1995 and 2000. These changes in landuse structure show the acceleration of urbanization and the tendency of degradation of eco-environment. Those also implicate the problems existing in the arrangement of

Table 3 Relative change degree of each landuse type of each region in Zhangye oasis

Land use type changed	Zhangye	Sunan	Minle	Linze	Gaotai	Shandan
Cropland	0.86	1.54	0.96	0.72	0.59	0.66
Woodland	1.77	0.01	1.15	0.01	1.02	0.32
Grassland	0.23	0.09	2.34	0.82	0.16	0.69
Water area	2.20	0.22	1.52	1.24	0.19	1.14
Urban and built up	0.95	0.74	1.81	0.04	0.28	0.68
Unused	1.35	0.81	4.90	1.18	0.29	0.73

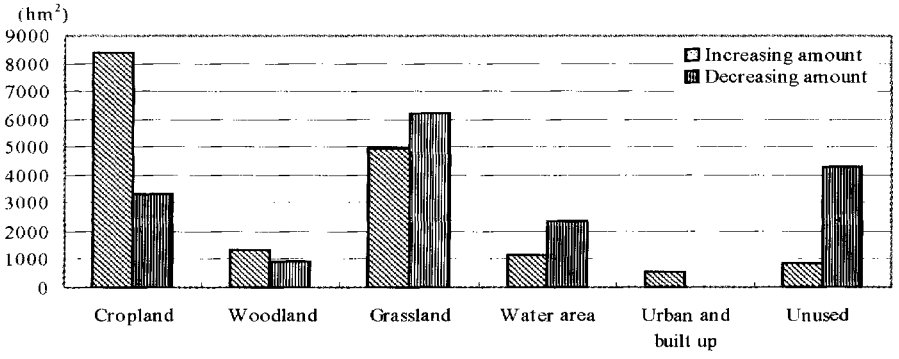

Figure 5 Landuse/landcover changes in Zhangye oasis in 1995-2000

land and water resources between the upper and lower reaches of the Heihe River.

(2) Regional differences of landuse/landcover are evident. Sunan County, located in the Qilian mountain areas, is characterized by the decrease of unused land and grassland and increase of cropland and urban and built-up area. While in low mountains and residual hills, Minle County and Shandan County are marked by the decrease of unused land, water area and grassland and increase of grassland and urban and built-up area. For Zhangye City, Linze County and Gaotai County, which are located in plain area of the middle reaches of the Heihe River, the LUCC appeared as a decrease in unused land, water area and grassland and an increase in woodland, cropland and urban and built-up area.

(3) The development of social economy is the main cause of the increase of urban and built -up area and cropland, including increase of population and GDP and per capita income etc. But for the decrease of grassland, woodland and water, the causes are relatively complex. The decrease of precipitation, the rising of temperature and the enlargement of investment in agriculture may all contribute to it. At the same time, some cropland and unused land were converted to grassland and woodland, which was mainly caused by ecological security and policies.

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