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Ecological Effects Associated with Land-Use Change in Urbanization Zone of Chengdu Plain

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Abstract: Research on land-use and land-cover change with associated effects on the eco-environment is a key to understanding global change. Urbanization is acknowledged as one of the most severe threats against ecosystem health. In this study, ecosystem service values are used to assess the ecological values of corresponding land-use types, so as to evaluate the ecological effects of regional land-use change and urbanization. Tourism-urbanization landscape of Chengdu plain comprises a transitional region in the urban-suburb eco-tone and has unique ecological functions covered with the characteristics of a fluctuant regional eco-environment, instability, complicated adjustment of ecosystem and sensitivity to exterior disturbance and interior elements. Consequently, land-use change and associated ecological effects must be monitored to assure sustainable development of this region. The landscape classification maps of Mt.Qingcheng Region were assessed based on land-use actual plats and actual condition in 1990 and 2003. The patch characteristics of the different land-use types and villages, urbanization expansion area and landscape diversity index were calculated based on models and GIS, thus examining the spatial patterns and dynamics of land-use in the study area. The results show the influences of human activities and natural environment factors. A moderate increase in forest and urban land in the last 13 years has resulted in the decrease of paddy field and dry land, some plow-lands are transformed into the rural resident buildings or urban land. Landscape diversity indices indicate that the proportions of each landscape element tend toward unbalance. The increase of urbanization expansion reveals that the effects of human activities. Ecological value calculations show that land-use change during these years has caused so many negative ecological effects with distinct spatial differences.

Key words: Land-use change, ecological effects, urbanization landscape, Chengdu plain, eco-environment, China

INTRODUCTION

The land-use study has the fundamental significance, as the land resources play a strategic role in the determination of man's economic, social and cultural progress. So the land-use of a region is always characterized by the spatial variations and is profoundly influenced by physic-socio-economic factors (Kapadnis, 2003). Since the IGBP and IHDP have presented the land-use/land-cover change plan this topic has rapidly attracted more attention. LUCC is an important component and the main cause of global environmental change (Chen *et al*., 2003) and the focus of advanced research on sustainable development (Liu and Chen, 2002). Consequently, the scholars not only pay attention to the classification of land-use and land-cover types, analysis and evaluation of LUCC in typical regions, dynamic monitoring of LUCC through RS and GIS and LUCC modeling at global or regional scales but also emphasize the eco-environmental effects of land-quality change and eco-environmental security patterns (Huang *et al*., 2002; Lv *et al*., 2001; Xia and Gar-On, 2004). LUCC can influence material cycles and energy flow in communities, impact biodiversity and important ecological processes in ecosystems and result in changes on the structures and patterns of the landscape (Jorg and Steffen, 2003). So it is of importance to study the relationship between the LUCC and the eco-environmental change and to maintain ecological balance and promote harmonious development of both the regional economy and the environment.

As the core contents of landscape ecology, analysis and evaluation of eco-environmental effects of LUCC for some typical regions (Islam and Weil, 2000) and in particular, the influences of the important ecological processes have become a major field in LUCC research. LUCC research focuses on quantitative analysis of the landscape pattern (Wang, 1998), while research into eco-environmental effects emphasizes

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functional change in landscape ecosystem (Shi *et al*., 2001; Turner, 1997), which is a part of the landscape process. The concept of ecosystem service is originated from one of the most important and advanced fields in ecology and eco-economy research at present. Since proposed by Costanza *et al*. (1997), the concept of global ecosystem services has been widely accepted and used. Ecosystem services constitute the natural condition and efficiency for human survival in the development of ecosystems and ecological processes. Costanza *et al*. (1997) calculated the mean economic value of the ecosystem services for 16 kinds of land-use and land-cover types. Thus, one can assess the ecological quality of regional land-use types according to the proportional relationship of the ecosystem services and then evaluate the ecological value change due to LUCC (Wu *et al*., 2006; Xia and Gar-On, 2004; Xie *et al*., 2001, 2006; Zhan *et al*., 2001).

Urban development, coupled with the growth of human population, threatens local and global ecosystems. The urban-suburb-country regions are considered as areas where human interference is at its highest level compared with other areas (Bolca *et al*., 2007), an increase in human population, a rise in resources utilization and expansion of urban spaces are the factors that affect the environment and ultimately cause significant changes in the landscape in short periods of time (Holdgate, 1993). Urbanization has been the dominant demographic trend in the last few decades in Chengdu plain. Towns and villages on the edge of Chengdu plain have become some of today's most popular tourism zones, where the effects of human activity are intensely felt and where conflicts between land use and natural resources most frequently take place. Developments of tourism industry drive and promote the spatial distribution and conglomeration of service industry and municipal establishments to the non-city zones. Tourism-urbanization landscape of Chengdu plain comprises a transitional region in the urban-suburb eco-tone and has unique ecological functions covered by the township fragmentations and agricultural irrigation network systems and with the characteristics of a fluctuating regional eco-environment, instability, complicated adjustment of ecosystem and sensitivity to exterior disturbance and interior elements.

The significant changes of land use and land cover could influence the structure and function of landscape ecosystems and result in profound changes to the regional eco-environment, particularly in an eco-social transitional zone. This striking feature can be observed typically in the Mt.Qingcheng Region. Consequently, it is the best case for the research on regional urbanization LUCC and its ecological effects with profound meaning for regional responses to eco-social environment change. Mt.Qingcheng Region in north Chengdu plain of Sichuan Province is chosen as the study area for analyzing the characteristics of regional land-use change and associated ecological effects from 1990-2003. The objectives of study are to identify land-use change processes in tourism-urbanization landscape of Chengdu plain those past 13 years through analyzing the dynamics of patch indices, landscape diversity indices and urbanization expansion and to study relative changes from the global mean economic value of the ecosystem service in order to evaluate the ecological effects of LUCC.

MATERIALS AND METHODS

Study area and materials: The study area, Mt.Qingcheng Region in north Chengdu plain of Sichuan Province (103°26'-103°39'E and 30°49'-30°55'N) is adjacent to Pengzhou city to the east, Wenjiang District to the south, Chongzhou city to the west and Wenchuan County to the north with the Minjiang River flowing through the region (Fig. 1). The squares from east to west and from south to north are 18.80 and 13.98 km, respectively. The total area is 95.00 km^2, mountains and hills occupies 69.50% of this area. Mt.Qingcheng Region has a low latitude and tropic warm-humid climate. As Mt.Qingcheng Region is located at the transitional zone extending from the low altitude of Sichuan Basin to the high altitude mountainous edge of Chengdu Plain and Sichuan Basin, the vegetation is abundant with some rare and preservative plant species survived after the Cretaceous period. This area, the habitat of ancient Ba and Su counties and the headstream and cradle land of Chinese Taoism is now a World Cultural Heritage Site of UNESCO.

Agriculture in Mt.Qingcheng Region has a long history, its tourism has flourished since 1990 and tertiary industry is booming. Until the end of 2003, the population of the whole area was 27,242 including 92% agricultural population, while the number of tourism receptions was 713,200 in 2003. There are 2 towns as Qingchengshanzhen (QCSZ) and Qingchengxiang (QCX) with 21 administrative villages in Mt.Qingcheng.

Data on changes of land use in the study area can be obtained by analyzing the land-use actual plats of Mt.Qingcheng Region in 1990 and 2003 (scale 1:10 000) and social and economic information obtained by fieldwork and from the local statistical yearbook. Some revise has been done on some land-use types in parts of the region during the study as well. To meet the requirements of the analysis on the ecological effects of the land-use change in accordance with the ecosystem types, the land use in Mt.Qingcheng Region is classified into different types including paddy field (irrigated land situated on flat areas), dry land (without irrigated water or facilities but relying on natural precipitation), forest land (forests, shrub-land, open woodland, planted areas with

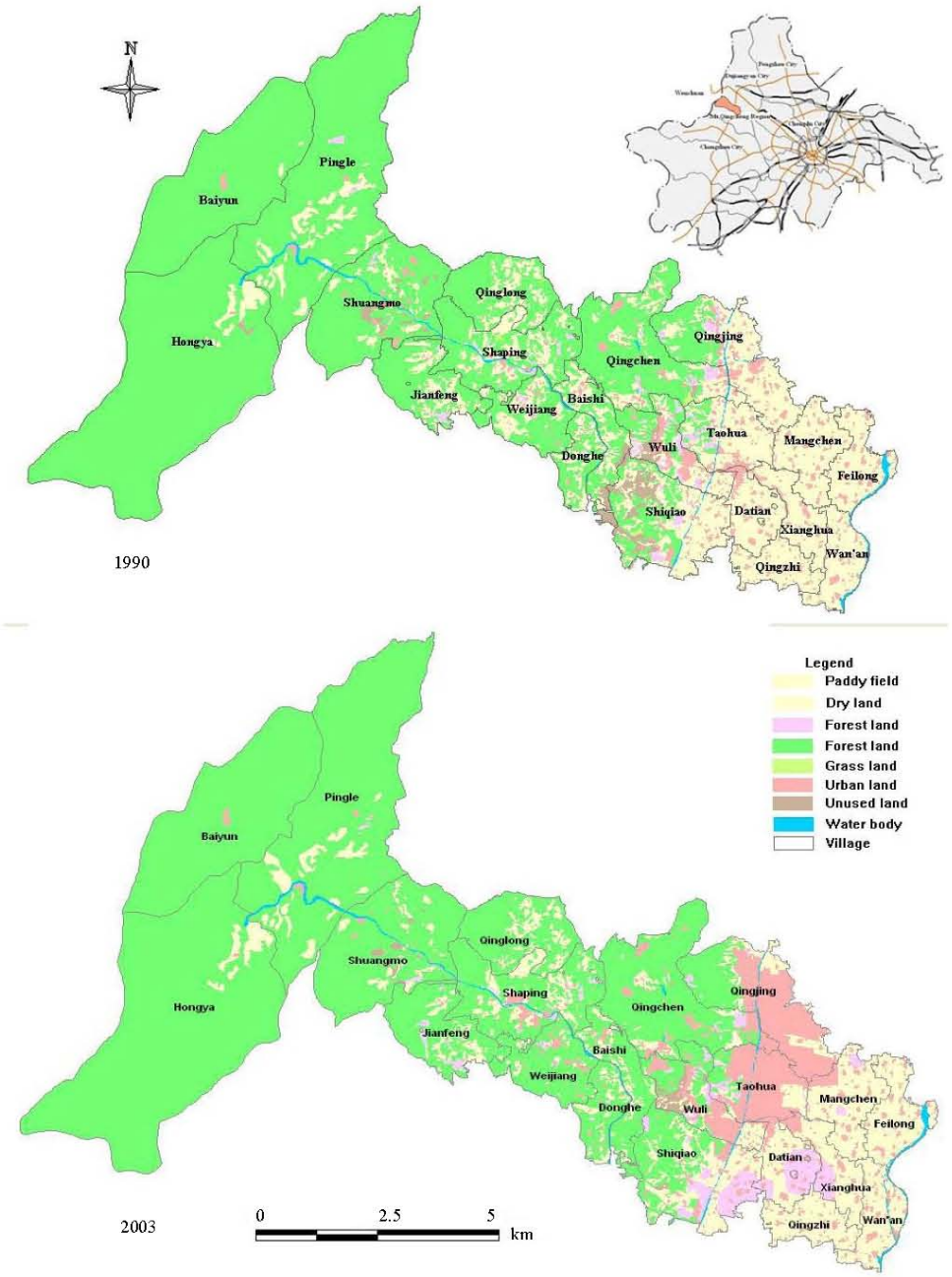

Fig. 1: Land use and land cover classification map in1990 and 2003 with locator map

young forest and nurseries, orchard and tea garden), grass land (natural grass land and pasture), water bodies (rivers, lakes, reservoirs and ponds), urban land (construction land, individual industry land, nterprise land, showplace and historic site land with its internal transportation and green land) and unused land (unused and land difficult to use, waste grassland, bare land, bare rock and sand dunes).

Analysis of land-use change: The purpose for this study is to build the GIS database and analyze landscape metrics of land-use types with the FRAGSTATS and ARC/INFO software so as to size up the actuality and dynamics of land-use patterns.

To reveal characteristics and dynamics of landscape patterns this study chose Shannon diversity index, Pielon uniformity index and Gleason richness index as common indices in the analysis of landscape patterns. For the

Table 1: Ecosystem services value unit area of different ecosystem types in the study area [a](¥· hm^{-2})

Ecosystem services	Paddy field	Dry field	Forest land	Grass land	Water body	Urban land	Unused land
Maintenance and regulation of air processes	442.4	401.6	3097.0	707.9	0.0	-	0.0
Moderates stream temperature variations	787.5	714.8	2389.1	796.4	407.0	-	0.0
Provides freshwater to downstream ecosystems	530.9	481.9	2831.5	707.9	18033.2	-	26.5
Soil generation and soil fertility	1291.9	1172.6	3450.9	1725.5	8.8	-	17.7
Detoxification and decomposition of wastes	1451.2	1317.2	1159.2	1159.2	16086.6	-	8.8
Biodiversity protection	628.2	570.2	2884.6	964.5	2203.3	-	300.8
Production of essential goods	884.9	803.2	88.5	265.5	88.5	-	8.8
Raw and processed materials	88.5	80.3	2300.6	44.2	8.8	-	0.0
Aesthetic, cultural value and recreation	8.8	8.0	1132.6	35.4	3840.2	-	8.8
Total	6114.3	5549.9	19334.0	6406.5	40676.4	-	371.4

[a] According to Costanza *et al.* (1997) and Xie *et al.* (2001), the value is adjusted to the actual condition of the study area

calculation and ecological meanings of these landscape metrics, please refer to Fu (1995) and Hargis *et al.* (1998).

Evaluation on ecological effects of land-use change: In this study, the appraisal of the ecological quality of regional land-use types, according to the proportional relation of global mean economic value of ecosystem service function proposed by Costanza *et al.* (1997) is conducted in order to establish the correlation among land use, land-cover and regional ecological quality and to derive a quantitative evaluation of the ecological effects of LUCC in general (Bi and Ge, 2004; Farber *et al.*, 2002).

Since there are some differences between global and Chinese mean ecosystem service function (Chen and Zhang, 2000; Wu *et al.*, 2006; Xia and Gar-On, 2004; Xie *et al.*, 2006; Zhang *et al.*, 2001) some essential revisions of the proportional relation of global mean economic value for ecosystem service function of land-use types according to the actual conditions have been done in the study area. These revisions are mainly due to plow-land in the study area includes paddy field and dry land and the ecosystem service functions of paddy field are much acuter than those of dry land; there are some urban and unused land in the study area, which were not valued both in the study area and in the study of Costanza *et al.* (1997). Finally, a set of ecological values of regional land-use types (Table 1) is obtained. The calculation of the total ecological value of regional land use through the weighted summation of the proportional areas of land-use types and their associated ecological effects of land-use change can be achieved during the study periods.

RESULTS AND DISCUSSION

Land-use change

Summary for land-use change: In the study periods, the grassland as one of land-use types in Mt.Qingcheng Region was vanished in 2003, some changes occurred in the land-use characteristics of the tourism-urbanization landscape at the same time. And there are now obvious changes in the areas of land-use types, i.e., a continual increase in urban land, forest land, while a rapid decrease in paddy fields and dry fields including some decreases in the area of unused land (Table 2). During the study periods, some changes in the basic characteristics of the tourism-urbanization landscape in Mt.Qingcheng Region have taken place, which reflects a high patch number, a small average area and average perimeter of patches. Area of urban land rapidly extends, from 34.88 hm^2 in 1990 to 429.07 hm^2 in 2003. This situation is partly due to the natural conditions of the study area. Mt.Qingcheng Region lies in the plain landform, it is easy to form patches in large areas, especially urban land and tourism reception sites and zones.

Among all the landscape elements except water body, the average patch area and average patch perimeter of forest land are the largest and most increasable with an increase in total area and the average patch perimeter and simultaneously a decrease in the number of patches. The increasingly large patches of forest land from other land-use types may come down to the artificial afforestation and forestry protection. In order to stimulate the tourism reception growth, some dry fields have been transformed to landscape forest. There are an obvious decrease in the total area of patches, while an obvious increase in patch members, accompanying a rapid reduction in average patch area of paddy fields.

The result shows that former paddy fields are occupied and scattered into small patches by irrigation channels and roads. Meanwhile, notable decreases in total area, numbers of diverse patches, average patch area and average patch perimeter suggest that dry land is occupied and transformed with the segmentation by other landscape elements, i.e., forest land and individual construction land and also scattered by roads. Grass land is a special landscape element in Mt.Qingcheng Region but gradually vanished in recent years and this situation suggests that there is a continual translation from grassland to others types, i.e., forests, orchard and tea garden in principle. The change in urban land is mainly manifested in the increase of total area of patches and there are some changes in average patch area, average patch perimeter and patch number, which turn the dispersive distribution patterns into the conglomerations of newly developed patches of urban land. The total area

Table 2: Summary for land-use change of land-use types in Mt.Qingcheng region from 1990-2003

Patch characteristics	Years	Paddy field	Dry field	Forest land	Grass land	Waterbody	Urban land	Unused land
Patch number	1990a	221.00	428.00	336.00	8.00	22.00	875.00	40.00
	2003a	451.00	405.00	289.00	-	34.00	813.00	33.00
Total area of patches (%)	1990a	15.62	10.22	66.79	0.11	0.83	4.84	1.60
	2003a	10.46	6.73	72.04	-	0.85	9.38	0.54
Average patch area (hm^2)	1990a	6.64	6.70	12.30	1.27	2.97	2.57	2.85
	2003a	2.18	1.17	14.12	-	1.78	3.63	0.77
Average patch perimeter (km)	1990a	1.74	2.28	1.95	0.55	2.21	0.85	0.97
	2003a	0.80	0.46	1.05	-	1.47	0.60	0.36

Table 3: Summary for land-use changes of villages in Mt.Qingcheng Region from 1990-2003 (hm^2)

	Patch number		MPS (mean patch size)			Patch number		MPS (mean patch size)	
Township	1990	2003	1990	2003	Township	1990	2003	1990	2003
Datian	56	100	3.30	1.72	Baishi	69	109	3.10	1.99
Feilong	85	148	2.56	1.40	Baiyun	8	2	109.00	434.05
Mangcheng	82	150	3.13	1.62	Donghe	81	113	1.78	1.32
Qingzhi	76	63	2.24	2.58	Hongyan	21	17	78.81	99.21
Shiqiao	207	273	2.43	1.78	Jianfeng	86	93	3.49	3.22
Taohua	127	87	2.05	3.07	Pingle	53	11	26.25	123.49
Wan'an	65	117	2.67	1.56	Qingcheng	138	51	4.28	11.53
Wuli	113	120	2.08	2.16	Qingjing	137	67	3.14	6.56
Xianghua	49	91	3.05	1.80	Qinglong	79	95	3.99	3.27
					Shaping	158	44	2.87	10.46
					Shuangmo	122	143	5.14	4.38
					Weijiang	118	131	2.15	1.91
QCX	860	1149	2.61	1.92	QCSZ	1070	876	20.33	62.46

of water bodies has not changed as compared with a fluctuation of patch number, average patch area and average patch perimeter. It suggests that the transition from water bodies to other land-use types just occurs in the small patches, therefore one may say that the water bodies to a certain extent are unchanged.

The total area of unused land obviously decreased with the reduction of patch numbers, average patch area and average patch perimeter. This suggests that in the process of land-use change, large patches of unused land have been divided into smaller patches and some paddy and dry fields have been discarded and become the unused land.

Summary for land-use change of various villages: From Table 3, one can identify some important processes of land-use change in various villages:

- In the QCX, there are some changes with growth of patch number and reduction of MPS in six villages as Datian, Feilong, Mangcheng, Shiqiao, Wan'an and Xianghua. So, the tendency of land-use change in the QCX is increase in patch number and decrease in MPS, which suggests dispersive distribution patterns have occurred in the newly developed patches. At the same time there are some changes: decreasing patch number and increasing MPS in two villages named Qingzhi and Taohua. This situation has been the only result of urbanization and industrialization, especially the town planning and construction in Taohua
- In the QCSZ, there are some changes with growth of patch number and reduction of MPS in six villages as Baishi, Donghe, Jianfeng, Qinglong, Shuangmo and Weijiang indicating that the distribution patterns of newly developed patches have been dispersed into the rural resident construction and the abandoned dry fields
- In the QCSZ, there are also notable changes with reduction of patch number and growth of MPS in Baiyun, Hongyan, Pingle, Qingcheng, Qingjing and Shaping. Human afforestation and landscape reestablishment have helped to bring about such a situation

The coexistence of urbanization and landscape reestablishment is a typical land-use characteristic of the urbanization landscape in Mt.Qingcheng Region. The dual increases of to ur reception and resident population leads to these complicated land-use changes in the study area.

Change of urbanization expansion and landscape diversity: Table 4 shows the urbanization expansion resulted from the development of tour industry and the growth of resident population was fast and evident. The urban land area reaches 275.78 hm^2 in the QCX with Taohua, 161.7 hm^2 and Wuli, 44.7 hm^2, respectively. A central business district has shaped in Taohua on the front region of Mt.Qingcheng beauty spot. Some Paddy field and dry field have been transformed

Table 4: Urbanization expansion and landscape diversity india from 1990-2003 (hm^2)

	Urbanization area			Shannon		Pielon		Gleason	
Township	1990	2003	Expansion area	1990	2003	1990	2003	1990	2003
Datian	16.50	31.80	15.30	3.35	4.00	3.05	3.64	0.58	0.58
Feilong	25.90	25.60	-0.30	3.61	4.37	3.29	2.72	0.56	0.94
Mangcheng	28.10	45.30	17.20	3.68	4.42	3.35	4.02	0.55	0.55
Qingzhi	16.90	19.10	2.20	3.51	4.30	5.06	6.20	0.39	0.39
Shiqiao	34.70	43.80	9.10	4.26	4.45	2.19	2.48	1.13	0.97
Taohua	22.80	184.50	161.70	3.91	3.21	2.18	1.79	1.08	1.07
Wan'an	20.70	26.10	5.40	3.32	4.02	3.02	2.90	0.58	0.77
Wuli	36.10	80.80	44.70	3.91	3.65	2.18	2.27	1.08	0.90
Xianghua	11.40	31.90	20.50	3.22	3.77	4.65	3.43	0.39	0.59
QCX	213.12	488.90	275.78	3.64	4.02	3.22	3.27	0.70	0.75
Baishi	6.90	9.00	2.10	3.25	3.64	1.81	2.03	1.12	1.12
Baiyun	15.80	4.50	-11.30	0.15	0.03	0.14	0.04	0.44	0.30
Donghe	6.90	7.00	0.10	3.27	3.45	2.03	2.14	1.00	1.00
Hongyan	1.70	1.20	-0.50	1.23	1.10	0.69	0.79	0.81	0.54
Jianfeng	4.60	4.60	0.00	2.79	2.65	1.43	1.91	1.23	0.70
Pingle	21.00	5.80	-15.20	1.45	1.41	0.75	0.88	0.97	0.69
Qingcheng	28.30	28.80	0.50	2.79	1.73	1.43	0.97	1.10	0.99
Qingjing	46.30	241.30	195.00	3.24	1.95	2.01	1.21	0.82	0.78
Qinglong	4.10	4.10	0.00	1.57	1.94	0.88	1.40	1.05	0.70
Shaping	18.80	28.60	9.80	3.29	3.38	1.69	2.10	1.14	0.82
Shuangmo	7.10	8.20	1.10	2.61	2.47	1.26	1.38	1.24	0.93
Weijiang	10.50	19.00	8.50	3.06	3.18	1.57	1.77	1.27	1.09
QCSZ	172.06	392.13	220.06	2.39	2.24	1.31	1.39	1.02	0.80

into the urban land covered by the rural resident buildings in Xianghua, Mangcheng and Datian. In the QCX, the urban land area reaches 220.06 hm^2 with Qingjing 195.0 hm^2. A central business district has shaped in Qingjing as Taohua with some paddy field transformed into the urban land because of the municipal construction and reception establishment. At the same time, some decreases of Pingle, 15.2 hm^2 and Baiyun, 11.3 hm^2 have taken place for congregating the rural resident spot and human afforestation.

During the period of the 13 years, the area for urbanization expansion of the whole region amount to 495.84 hm^2, which is 1.3 times more than the area in 1990. So, there forms a large comercial district of 550.8 hm^2, which is surrounded by Qingjing, Qingcheng, Wuli, Datian, Taohua and Mangcheng and provides the tourists and residents with plenty of goods and excellent service. The landscape diversity index reflects the difference between the amounts and proportions of various landscape elements. Generally speaking, a high value means that the proportion of various landscape elements is balanceable. The degree of Shannon index in Mt.Qingcheng Region is binary on the whole. With corresponding high degree of 3.64-4.02 in QCX, the Shannon index rises continuously as a whole, while Taohua and Wuli declining (Table 4), which reflects a balanced landscape structure as a result of human activities. For relatively low degree of 2.24-2.39 in QCSZ, the area of each landscape element is comparatively out of balance in proportion, especially for the vast growth of the urban land in Qingjing. Pielon uniformity index reflects the correlation of every given type and its number of landscape elements. In general, a large value for this index means that the landscape is composed of the same number patches of every land-use type in contrast, it represents a landscape including only one type. Plowland (paddy field and dry land), forest land and urban land are 3 dominant types in shaping landscape. Rapid reduction in plowland and continuous growth in forest land and urban land lead to a slow increase in the degree of evenness for each one element during the past >10 years. Gleason richness index reflects the correlation of type number and total number of elements in the landscape. The value of Gleason richness index varies irregularly, which reflects the continuous strengthening of human distribution in the process of landscape change. As shown in Table 4, the Gleason richness index shows how heavy the pressure from human distribution is throughout the study period. Human-managed types which shape a landscape are responsible for the decrease of the richness index. The fact supports a theory that the random effects of human disturbance have converted heterogeneous patches into homogeneous patch mosaics. The increase in the Gleason index is mainly due to the division of large patch mosaics in the different landscape elements or land-use types.

Ecological effects of land-use change

Integrated ecological effects of land-use change in the whole county: From Table 5, one can know that the ecological value of land use in Mt.Qingcheng Region is considerably captivating. The decrease of ¥ 2942.95×10^4 at an annual average rate of 1.63% is a impressive figure. The land-use change in the region records the

Table 5: Change in ecological value of land use in Mt.Qingcheng region from 1990-2003

	Ecological value							
	Paddy field		Dry land		Forest land		Grass land	
Township	1990	2003	1990	2003	1990	2003	1990	2003
Datian	93.94	37.08	-	0.55	-	66.72	-	-
Feilong	105.60	46.93	2.87	17.92	-	6.48	-	-
Mangcheng	136.08	55.66	1.53	4.41	1.42	15.64	-	-
Qingzhi	91.55	46.06	1.29	2.36	-	-	-	-
Shiqiao	75.21	53.62	56.54	68.57	285.28	217.66	1.52	-
Taohua	78.06	24.28	21.20	8.39	100.52	353.61	-	-
Wan'an	84.27	18.50	1.95	1.44	-	-	-	-
Wuli	20.45	46.10	20.94	36.17	208.97	136.63	-	-
Xianghua	77.20	31.42	0.33	1.56	-	37.89	-	-
QCX (Baishi)	762.36	359.65	106.65	141.37	596.20	834.64	1.52	-
Baishi	-	-	40.22	27.78	201.87	208.01	-	-
Baiyun	-	-	2.21	-	1669.35	1669.66	-	-
Donghe	-	-	24.27	34.32	180.98	110.26	-	-
Hongyan	-	-	27.12	24.08	3092.11	3213.50	-	-
Jianfeng	-	-	39.85	100.53	432.29	93.90	0.23	-
Pingle	-	-	61.08	428.85	2432.56	1064.37	-	-
Qingcheng	13.55	-	44.50	119.65	849.98	513.94	2.42	-
Qingjing	121.58	110.95	21.76	111.25	263.94	17.38	-	-
Qinglong	-	-	42.03	109.34	451.02	113.79	0.77	-
Shaping	-	-	59.67	115.87	623.75	301.97	1.44	-
Shuangmo	-	-	25.46	164.63	1022.68	449.80	-	-
Weijiang	-	-	38.05	40.29	318.22	203.61	0.15	-
QCSZ								
Whole area	135.13	110.95	426.22	1276.59	11538.75	7960.19	5.02	-
Whole region	897.50	470.60	532.86	1417.96	12134.95	8794.83	6.53	-

	Ecological value							
	Water body		Unused land		Total value		Change	
Township	1990	2003	1990	2003	1990	2003	Amount	%
Datian	-	-	-	-	93.94	104.35	10.41	11.08
Feilong	44.00	34.61	-	0.30	152.47	106.24	-46.23	-30.32
Mangcheng	-	-	-	-	139.03	75.72	-63.31	-45.54
Qingzhi	-	-	-	-	92.84	48.42	-44.42	-47.85
Shiqiao	18.31	32.22	3.24	0.18	440.10	372.25	-67.85	-15.42
Taohua	12.47	1.61	-	-	212.26	387.89	175.63	82.74
Wan'an	25.72	89.33	-	0.58	111.94	109.85	-2.09	-1.87
Wuli	3.97	8.46	0.14	0.06	254.48	227.42	-27.06	-10.63
Xianghua	-	-	-	-	77.53	70.86	-6.67	-8.60
QCX (Baishi)	104.47	166.23	3.38	1.12	1574.59	1503.00	-71.59	-4.55
Baishi	16.73	1.19	0.95	0.05	259.76	237.03	-22.73	-8.75
Baiyun	-	-	-	-	1671.56	1669.66	-1.90	-0.11
Donghe	-	7.50	-	-	205.25	152.07	-53.18	-25.91
Hongyan	7.35	7.35	0.12	-	3126.70	3244.93	118.23	3.78
Jianfeng	-	-	-	-	472.37	194.43	-277.94	-58.84
Pingle	71.24	6.21	-	-	2564.88	1499.43	-1065.45	-41.54
Qingcheng	28.80	46.06	0.15	0.01	939.40	679.66	-259.74	-27.65
Qingjing	5.22	2.26	-	-	412.50	241.84	-170.66	-41.37
Qinglong	-	-	0.01	-	493.82	223.13	-270.69	-54.82
Shaping	25.83	7.18	-	-	710.69	425.02	-285.67	-40.20
Shuangmo	31.70	26.32	0.97	0.12	1080.81	640.88	-439.93	-40.70
Weijiang	33.44	4.25	-	-	389.86	248.16	-141.70	-36.35
QCSZ								
Whole area	220.31	108.32	2.19	0.18	12327.60	9456.24	-2871.36	-23.29
Whole region	324.78	274.55	5.58	1.31	13902.19	10959.24	-2942.95	-21.17

undesirable ecological effects of deterioration in either the landscape structure or landscape function in accord with the actual conditions. If rapid economic development is at the cost of degradation in the environment as a rule this development cannot be sustainable in the terms of LUCC. In QCX, the result shows that the ecological value forland use decreases ¥ 71.59×10^4, occupying 2.43% of the total region with the growth of forest land, dry land and water body, while the reduction of the paddy field. When the ecological value of land use keeps decreasing, paddy field decreases faster or is being replaced by urban land in the ordinary course of events no ecological value remains. In QCSZ, the changes show that the ecological value of land use decreases at the proportion of 97.57%

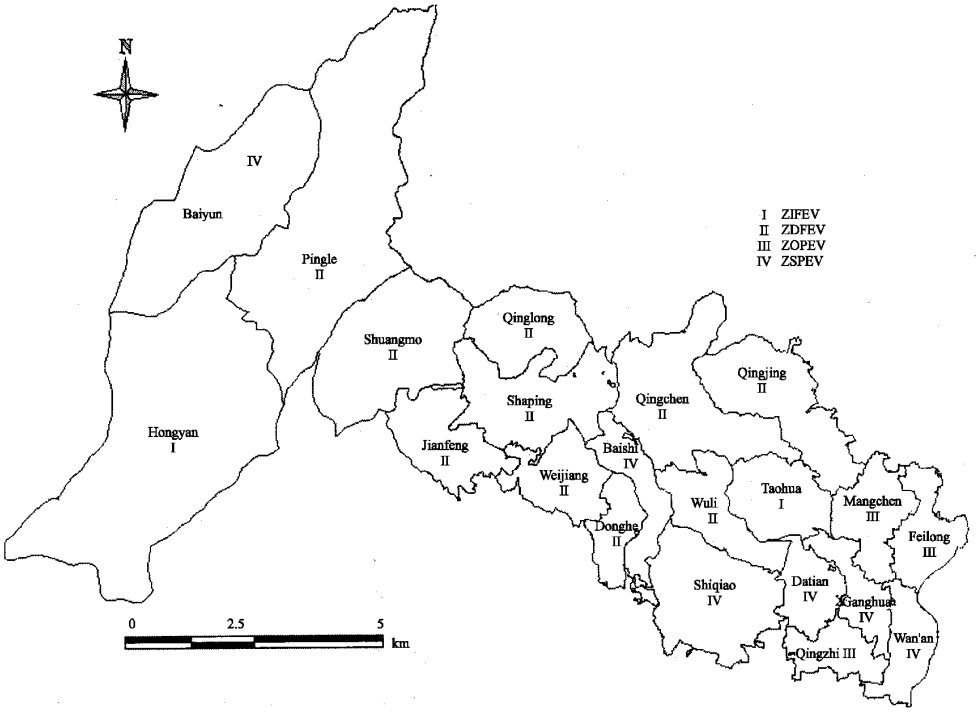

Fig. 2: Spatial differentiation of the change of ecological value in Mt.Qingcheng region

in the total region with the decreasing paddy field, forest land, water body and unused land and 2.66 times increasing dry land. The ecological value decreases severely this fact is simply because of the forest land's decrease of ¥ 3340.12×10^4.

Spatial differentiation of ecological effects on land-use change: From Table 5, one can also see that various villages of Mt.Qingcheng Region differs greatly with a decrease in the relative difference in the study periods. The ecological values of land-use in different villages fluctuate in a range from ¥ 77.53~3126.7×10^4 (year 1990) to ¥ 70.86~3244.93×10^4 (year 2003). There are also obvious spatial differences in the ecological effects of land-use change in all 21 villages, which have become an important basis for sustainable development. According to the change of ecological value arisen in the study periods, all 21 villages of Mt.Qingcheng Region can be classified into four types (Fig. 2):

- Zone in increase by growth of forest land of ecological value (ZIFEV). In this zone, the ecological value of land use increases continuously during the study periods. It includes 2 villages, Hongyan and Taohua. The increase in ecological value is mainly resulted from a continuous increase of forest land and decrease of plowland (Paddy field and Dry land)
- Zone in decrease by reduction of forest land of ecological value (ZDFEV). In this zone, the ecological value decreases at the different degrees. It includes 10 villages, Wuli, Donghe, Jianfeng, Pingle, Qingcheng, Qingjing, Qinglong, Shaping, Shuangmo, Weijiang. However, the decrease in ecological value is not the result of reclaiming forest land to economic plant as tea, Chinese medicinal materials and others, which contribute to the transition from forest land to dry land but of turning the forest land into rural resident buildings, travel establishmenst and recreational real estates mainly. In Pingle, Qingcheng and Qingjing, recreational real estates and reception establishments have had a enormous developent in the past ore than 10 years
- Zone in decrease by reduction of plowland of ecological value (ZDPEV). It includes 3 villages, Feilong, Mangcheng and Qingzhi. In this zone, the transformation of paddy field and dry land into rural resident buildings has played a crucial role in the ecological value change
- Zone in some fluctuation of ecological value (ZSFEV). It includes 6 village, Datian, Shiqiao, Wan'an, Xianghua, Baishi and Baiyun. In this zone, the ecological value of land use decreases mainly because of re-patterning in forest land and plowland (paddy field and dry land)

CONCLUSION

The study in Mt.Qingcheng Region indicates that the major land-use changes are the continuous increase in forest land and urban land, while the rapid decrease in paddy field and dry land, simultaneously an inter-transition between plow-land and urban land also occurs frequently. The decreasing trend in the landscape diversity index means that the proportion of each landscape element has changed to imbalance and the effect of human activity on the environment has become strong.

The main driving force for land-use change in human activity in addition to urbanization expansion and human afforestation. All these factors have resulted in a continuous increase of forest land and urban land. Tourism industry elements, such as planting forest landscape, building recreational establishment and transportation system are the dominant factors in the process of land use and cover change, the most important decisive factor for change. In QCX, urban land as central business district and reception facilities surrounds the glacis of the scenery spot because of the strict management, while the fragmental patches of recreational real estate are distributed in QCSZ for tour economic benefit. So, the increase and decrease of land use would continuously coexist together.

Ecological value calculation shows that land-use change has led to negative ecological effects and the development is non-sustainable in term of LUCC. Changed land use in the study area during these years has caused detrimental effects to the existing natural and cultural structure. Distinct spatial differentiation is an important basis for ecological planning for sustainable development. And the ultimate goal is to keep up sustainable development of the landscape economy.

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