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Impact characteristics of human disturbance on land-use and landscape ecology pattern, Lushan, Southwest China

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Abstract. This paper, on the basis of results achieved recent years related to interaction mechanism of landscape pattern and ecological process from the study area, mainly studies evolution characteristics of the landscape pattern in Lushan County, Southwest China after earthquake with the support of landscape ecology method and the GIS technology. Through data-analysis at three phases, it is concluded that there exists a positive correlation between the land use change of the earthquake-stricken areas and the intensity of human disturbance and between the change of landscape pattern index and the intensity of human disturbance; that there is, in the landscape pattern of the earthquake-hit areas, a trend of good landscape "encircling" and "dispersing" bad landscape under the influence of human disturbance; and that human disturbance exerts positive effects on the ecological restoration from 2008 to 2012 and from 2013 to 2017, but negative effects from 2012 to 2013.

1. Introduction

Study of relationship and coupling mechanism between landscape pattern and ecological evolution process is one of core scientific issues in landscape ecology [1-3] while the grasp of the interaction mechanism between landscape pattern and ecological evolution process is the key to further the study of landscape ecology [4-5]. Driving factors of landscape changes can affect the development of landscape pattern [6-7] and are usually categorized into 2 classes: natural factors and human factors, of which natural factors include climate, hydrology, changes in soil environment and etc. and human factors include population, technological progress, changes in the political and economic system, cultural shifts and the like. In most foreign studies, driving factors are divided into five major categories [8-9], namely, economy, policy, science and technology, culture, and nature, and great emphasis is usually placed on those human driving factors [10-11]. The relationship between driving factors and landscape change is not a simple one-to-one, but rather a one-to-many, many-to-one or even many-to-many relationship [6].

Landscape change is a combined result of natural and human disturbance with human activities' influence on landscape change especially prominent [12]. Apart from the abundance, distribution and viability of species in the landscape, human activities also have an impact on ecological processes in the landscape and edge effects [13-14]. Human disturbance, as a manifestation of human activities in a certain period of time and in a certain space, is one of the driving factors in the ecological process. The evolution and change of landscape caused by human disturbance tend to be very obvious, and in a short period of time, changes brought by human disturbance are even so remarkable that those triggered by natural driving factors are covered up. Through this research, we can find the interaction



mechanism between landscape pattern and ecological process. At present, most studies both at home and abroad tend to employ landscape pattern index and landscape dynamic change model to study the evolution of landscape pattern. Among the two research tools, the landscape pattern index, as one of the most important indicators in landscape research, serves as a profile of landscape-relevant information. It is a quantitative index reflecting landscape structure and composition, and characteristics of its spatial distribution.

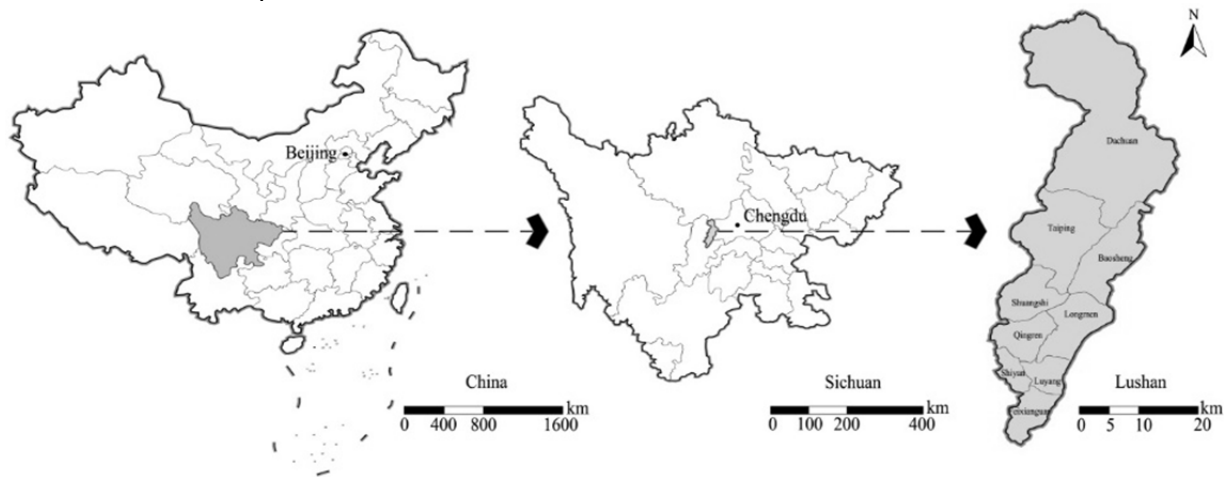


Figure 1. Location of the Lushan, west Sichuan, southwest China.

2. Materials and methods

2.1. Overview of the study area

Lushan County is located in the west of Sichuan Province, southwestern China with latitude ranging from 30 ° 01' to 30 ° 49 'N, longitude 102 ° 52 'to 103 ° 11'E. Situated in the transition zone between Sichuan Basin and Qinghai-Tibet Plateau, Lushan County with an elevation ranging from 686 to 3842 meters (see Figure 1) is low in the south and east and high in the north and west. Based on 10 remote sensing images from 2008 to 2017, authors, taking consideration of the characteristics of landscape pattern in Lushan County, develops a land classification system to categorize land use of Lushan County into 9 types, namely, unused land, wood land, arable land, wetland, grassland, water body, construction land, residential land and bare mountain.

2.2. Basic data sources

The remote sensing imagery data, Landsat7ETM + and Landsat8 OLI image data with the precision at 10m combined with field survey data, are used to develop a landscape grid database supplemented by unified projection co-ordinates after image correction, image splicing, and multi-source data fusion. Land area and population data are collected from such government departments as Bureau of Statistics of Lushan County, Land Bureau of Lushan County and Housing and Urban-Rural Development Bureau of Lushan County.

2.3. Data pre-processing

Land classification is based on computer automatic classification and manual classification. With the support of Erdas Imagine 9.0, the images are preliminarily classified before modified by visual interpretation with such supplementary data as topographic maps and vegetation maps to achieve an accurate classification. Authors use ArcGIS10.2 software to edit the map and help carry out a digitized analysis, and finally completes with land use distribution images of 9 types, namely unused land, wood land, arable land, wetland, grassland, water body, construction land, residential land and bare mountain.

2.4. Data analyses

2.4.1. Calculation of land use dynamic change index. In this paper, comprehensive dynamic change degree of land use is used to describe the change intensity of one land use type during a specific period. Through analyzing changes of land use type, we can get hold of the disturbance level of human disturbance on such land, and through analyzing changes of areas dedicated to different land types, we can see the influence of human disturbance on different land use types in different periods. See formula (1) [15].

$$LC = \frac{\sum_{i=1}^n \Delta LU_{i-j}}{2 \sum_{i=1}^n LU_i} \times \frac{1}{T} \times 100 \% \quad (1)$$

LC represents the comprehensive dynamic change intensity of land use during the study period; LU_i , the quantity of land dedicated to category i land use type at the beginning of the study; ΔLU_{i-j} , the absolute value between the quantity of land dedicated to category i land use type and that converted into non-category i land use type within the study period; and T for the study period length.

Table 1. Landscape type with respect to hemeroby index.

Level I	Level II	HI(hemeroby index)
Undisturbed (almost undisturbed by human)	Unused land	0.10
	Woodland	0.20
	Grassland	0.30
Partially Disturbed (where human and nature impacts played equal roles, such as Farm and Aquacultural, etc.)	Wetland (wetland and river flood plain)	0.40
	Waterbody (river and reservoir)	0.50
	Arable land	0.60
	Road and Concrete slope	0.70
Completely Disturbed (man-made entities like paved roads, etc.)	Residential land (town and village)	0.80
	Construction land	0.90
	Bare mountain	0.95

Note: $0 < HI < 1$, 0 means undisturbed at all, and 1 means completely disturbed.

2.4.2. Calculation of human disturbance index. Disturbance intensity refers to the intensity of human disturbance. The smaller the disturbance intensity, the more conducive to biological survival, and thus, the greater the ecological significance for the receptor. On the basis of previous researches, authors employ the hemeroby index, referred to as HI, to make human disturbance index assignment for the 10 types of land use with road and concrete slope protection included, after taking account of actual conditions of the study area. (for details, please see Table 1).

Human disturbance intensity for each grid (patch) can be calculated by putting assignments into formula (2):

$$D = \frac{\sum_{i=1}^m HI_i \cdot S_i}{S} \quad (2)$$

D refers to the human disturbance intensity of a grid (patch), HI_i , the disturbance index of the i -type landscape, S_i the acreage of the i -type landscape, and S , the total area of all grids (patches). The intensity of human inference is a demonstration of the impact of human disturbance on the change of landscape pattern.

3. Results and analyses

3.1. Analysis on dynamic change of land use

3.1.1. Land area change characteristics. The following information can be concluded from data in Figure 2 and Figure 3:

Unused land area sees a continuous increase; from 2008 to 2012, and a continuous decrease from 2013 to 2017; wood land area sees a slight increase after a sustained decrease from 2008 to 2017; grassland and bare mountain witness a significant cut-down from 2012 to 2013, but an overall increasing growth rate from 2008 to 2017; residential land area experiences a continuous increase from 2008 to 2017. Farmland area sees a continuous decrease from 2008 to 2012 while a continuous increase from 2013 to 2017 with the increased area slightly larger than the reduced area. Area of wetlands witnesses a significant drop from 2012 to 2013, but an overall growth trend from 2008 to 2017, with the increased area slightly larger than the reduced area; the construction land area continues to increase from 2008 to 2014, and declines from 2015 to 2017.

3.1.2. Land use dynamic change characteristics. The following information can be concluded from data in Figure 4:

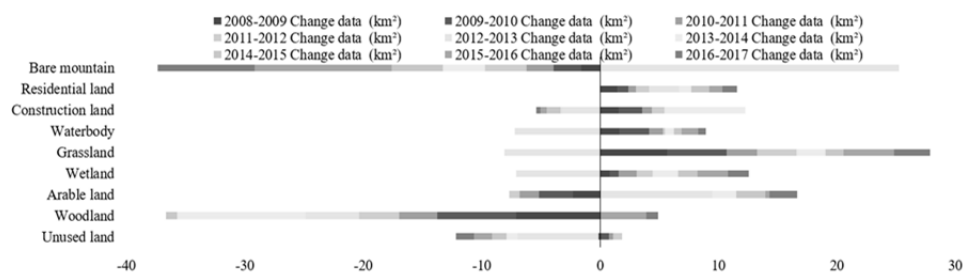


Figure 2. 2008-2017 Land area change characteristics in different years.

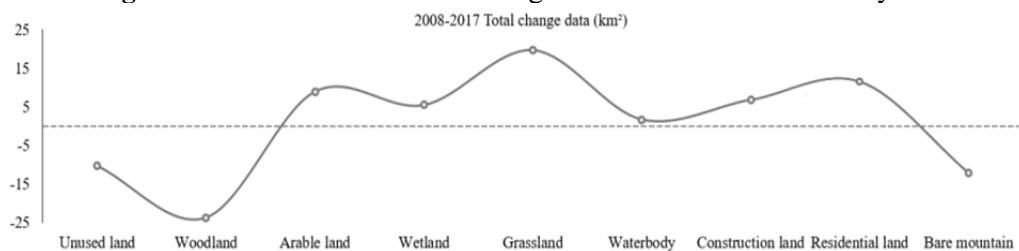


Figure 3. 2008-2017 Land area total change characteristics.

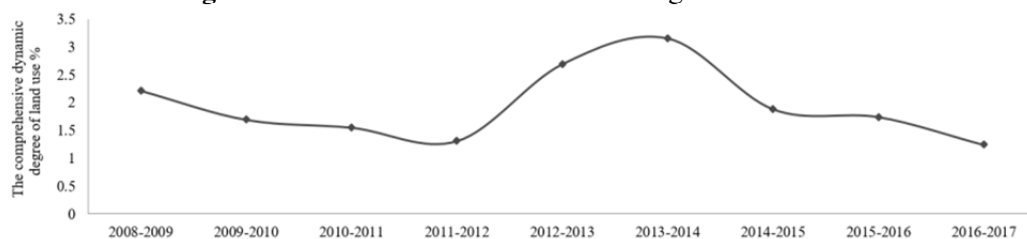


Figure 4. 2008-2017 The dynamic change of the comprehensive dynamic degree of land use.

The dynamic degree of land use change of Lushan County from 2008 to 2012 are 2.21%, 1.69%, 1.55% and 1.31% respectively, showing a downward trend; 2.69% and 3.15% respectively from 2012 to 2014, showing an upward trend; 1.88%, 1.74% and 1.24% respectively from 2014 to 2017, showing another downward trend. As a whole, the trend of comprehensive dynamic change degree of land use from 2008 to 2017 shows a " $\wedge$ " shape with a downward trend at first, then upward trend and another downward trend.

3.2. Analysis of landscape pattern index change

3.2.1. Characteristics of Landscape Pattern Index Change. The following information can be concluded from data in Table 2:

The *PD* of unused land, farmland, wetland, grassland and water body sees an increase from 2008 to 2012, a decrease in 2013 before another increase from 2013 to 2017. Among the above said 5 land use types, *PD* of unused land, farmland and water body changes at a slight scale while wetland and grassland at a relatively great scale. *PD* of wood land has been on the decline from 2008 to 2017. The *PD* of construction land and bare mountain sees a decrease from 2008 to 2012, then a sharp increase in 2013 before a continuous decline from 2013 to 2017. Area of both types of land use varies greatly. The *PD* of residential land has been on the rise from 2008 to 2017.

Table 2. 2008-2017 Landscape structure indices in Lushan county.

Year	Index	Unused land	Woodland	Arable land	Wetland	Grassland	Waterbody	Construction land	Residential land	Bare mountain
2008	<i>PD</i>	0.0681	0.7358	5.0518	0.0164	0.0437	0.0272	2.6174	7.8138	6.3438
	<i>LPI</i>	0.1747	29.5181	0.0258	0.1478	0.1636	0.0447	1.5787	2.1623	1.0267
2009	<i>PD</i>	0.0724	0.7234	5.1507	0.0172	0.0489	0.0284	2.6051	7.8896	6.0412
	<i>LPI</i>	0.1705	30.2462	0.0267	0.1503	0.1702	0.0455	1.5603	2.2345	1.0243
2010	<i>PD</i>	0.0766	0.7166	5.2491	0.0179	0.0506	0.0304	2.5137	7.9172	5.8371
	<i>LPI</i>	0.1622	31.0464	0.0298	0.1567	0.1755	0.0466	1.5433	2.3309	1.0227
2011	<i>PD</i>	0.0807	0.7035	5.5488	0.0185	0.0523	0.0316	2.4232	7.9608	5.6363
	<i>LPI</i>	0.1568	32.1113	0.0319	0.1622	0.1801	0.0476	1.5316	2.4835	1.0201
2012	<i>PD</i>	0.0823	0.6985	5.9476	0.0196	0.0578	0.0328	2.4127	8.0227	5.0331
	<i>LPI</i>	0.1428	32.4255	0.0339	0.1687	0.1829	0.0482	1.5226	2.5727	1.0193
2013	<i>PD</i>	0.0608	0.6881	4.8537	0.0134	0.0502	0.0269	2.7201	8.6246	7.7512
	<i>LPI</i>	0.1819	28.1078	0.0396	0.1352	0.1716	0.0455	1.6163	2.6757	1.0337
2014	<i>PD</i>	0.0683	0.6813	5.3559	0.0164	0.0524	0.0278	2.6883	8.6364	7.1475
	<i>LPI</i>	0.1724	28.7732	0.0405	0.1462	0.1786	0.0458	1.5907	2.7035	1.0291
2015	<i>PD</i>	0.0732	0.6734	5.7583	0.0188	0.0569	0.0286	2.6272	8.7692	6.7428
	<i>LPI</i>	0.1635	29.5366	0.0432	0.1583	0.1806	0.0461	1.5467	2.8899	1.0265
2016	<i>PD</i>	0.0764	0.6701	5.9617	0.0203	0.0593	0.0291	2.6052	8.9412	6.5391
	<i>LPI</i>	0.1537	30.2472	0.0455	0.1672	0.1904	0.0463	1.4835	2.9346	1.0233
2017	<i>PD</i>	0.0775	0.6608	6.1629	0.0245	0.0611	0.0298	2.4502	9.0427	6.2364
	<i>LPI</i>	0.1471	31.5938	0.0476	0.1728	0.1959	0.0462	1.4037	3.2061	1.0214

Table 3. 2008-2017 Landscape level indices in Lushan county.

Year	<i>FN</i>	<i>DI</i>	<i>CONNECT</i>	<i>CONTAG</i>	<i>SHDI</i>	<i>SHEI</i>
2008	0.4923	40.1543	70.2316	42.7511	1.5727	0.3255
2009	0.4678	40.8872	70.8063	44.6782	1.4908	0.3654
2010	0.4327	41.3567	71.6704	46.3278	1.4146	0.4213
2011	0.4037	42.768	72.9055	49.2058	1.3083	0.5566
2012	0.3768	43.7191	73.4543	51.6936	1.2658	0.6209
2013	0.5958	39.3605	67.4017	39.4124	1.7836	0.2187
2014	0.5034	40.2318	69.3083	42.0086	1.6213	0.3064
2015	0.4621	42.0136	70.6544	45.6083	1.5237	0.3951
2016	0.4057	43.2056	71.4298	46.2156	1.5027	0.4512
2017	0.3288	44.2329	72.9252	49.8607	1.3976	0.5747

The *LPI* of wood land, wetland, grassland and water body witnesses an increase from 2008 to 2012, a decrease in 2013 before a continuous rise from 2013 to 2017. The *LPI* of unused land, construction land and bare mountain sees decrease from 2008 to 2012, then sharply rise in 2013 before continuously decline from 2013 to 2017 with unused land's fluctuation amplitude being slight and that of construction land and bare mountain being great; *LPI* of arable land and residential land has been on the rise from 2008 to 2017.

The following information can be concluded from data in Table 3: *FN* and *SHDI* see a decrease from 2008 to 2012, then an increase from 2012 to 2013 before another decrease from 2013 to 2017. The reason behind the above mentioned trend is that landscape pattern was affected by human disturbance, say, post-disaster reconstruction works proceeded from 2008 to 2012, while by 2012, as the first post-disaster reconstruction completed, the original natural broken patches were replaced by a large number of construction patches and by 2017, as the second post-disaster reconstruction

completed, and Lushan County entered into the stage of ecological quality improvement, and more residential land patches and farmland patches appeared.

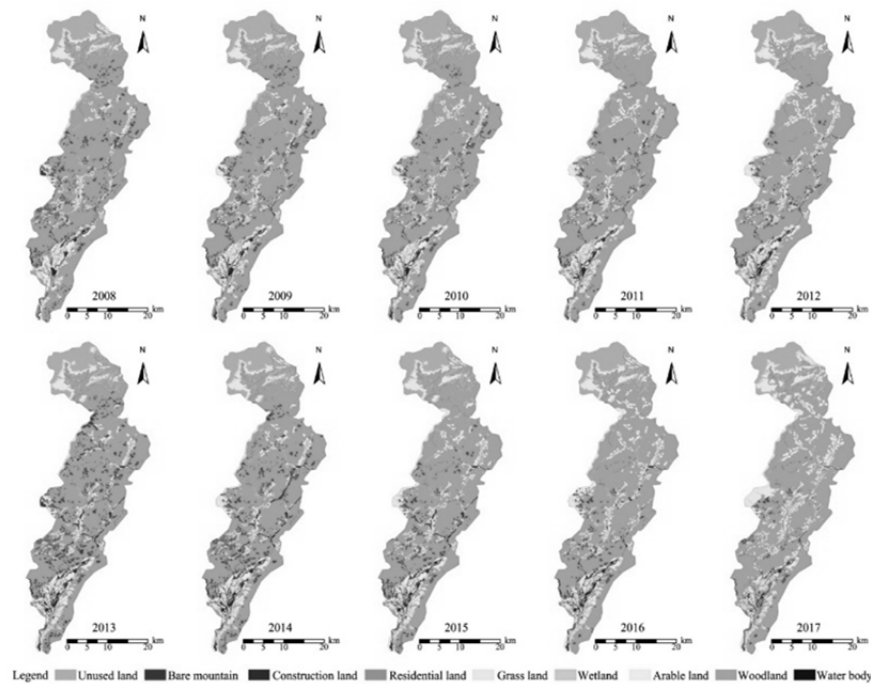


Figure 5. Spatial distribution map of Lushan land use.

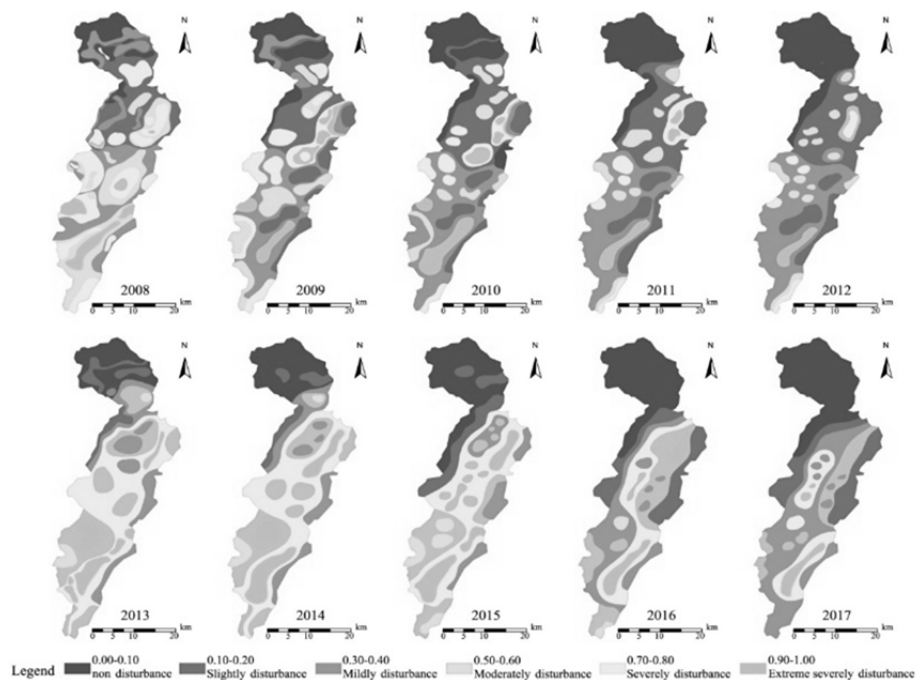


Figure 6. 2008-2017 Landscape pattern human disturbance spatial distribution.

DI, *CONNECT*, *CONTAG* and *SHEI* saw an increase from 2008 to 2012, a decrease from 2012 to 2013 before another increase from 2013 to 2017. The above-mentioned trend is mainly caused by the increase and advantageous position of construction patches, residential land patches, and farmland patches. Furthermore, as the original natural broken patches are dispersed, connected by newly-built roads and concrete slope protection, in other words, new connecting corridors of the landscape, new

landscape pattern comes into being and under human disturbance, begins to self-expand and self-perfect.

Characteristics of landscape pattern spatial distribution. The following information can be concluded from data in Figure 5:

By 2012, that bare mountain begins to decrease in size and presents with a scattered distribution, is mainly due to human intervention since restoration works aiming at renovating ecological environment, say, construction of a great quantity of concrete slope protection and artificial vegetation, are carried out. That the south region experiences an increase of construction land, farmland and residential land is mainly caused by the increase construction land, which leads to a gradual reduction of wood land from north to south.

By 2017, concrete slope protection and roads decrease and begin to impose a weakened damaging effect on the landscape ecology. The urban construction in the southern Lushan County leads to occupation of a large amount of farmland, resulting in a substantial reduction of farmland in the south and continuous expansion of farmland towards central and northern regions, upsurge of new residential land and construction land, gradual increase of wetland in the northern region, unused land and grassland mainly concentrating in the northern alpine region, and gradual decrease trend of forest area from north to south.

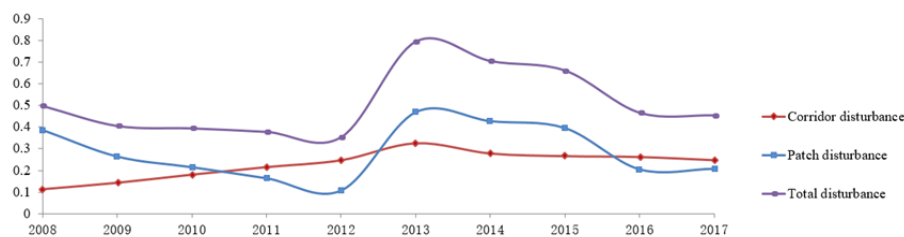


Figure 7. 2008-2017 human disturbance index.

3.3. Analysis of landscape pattern by human disturbance

The following information can be concluded from data in Figure 6: The human disturbance intensity of patches for year of 2008 to 2012 are 0.385, 0.263, 0.214, 0.163 and 0.107 respectively, showing a continuous downward trend, which indicates that human disturbance imposes a weaker effect on corridor than on patches; the comprehensive disturbance intensity for year of 2008 to 2012 are 0.498, 0.406, 0.395, 0.359 and 0.355 respectively, showing a continuous downward trend, mainly due to the valley area being the area that is disturbed most frequently. In the early stage, the central and southern regions are moderately, severely or extremely disturbed and most of the above-mentioned regions are distributed in the two sides of the river valley. In the northern regions, most are mildly disturbed with few regions severely disturbed. The slightly disturbed regions are distributed from north to south, concentrating in the north and relatively decentralizing in the south.

The disturbance intensity of patches for year of 2013 to 2017 are 0.468, 0.426, 0.344, 0.204 and 0.207 respectively, showing a rapid downward trend, which indicates that human disturbance imposes a very fast effect on a single patch; the comprehensive human disturbance intensity for year of 2013 to 2017 are 0.795, 0.703, 0.661, 0.467 and 0.455 respectively, showing a rapid downward trend, which demonstrates a rapid decline in construction volume. From 2013 to 2017 before the second post-disaster reconstruction begins, middle of Lushan County is mainly severely disturbed, the south, mainly moderately, severely or extremely disturbed. The distribution of human disturbance shows homogenization trend at the later period. The moderately, severely and extremely disturbed areas are mainly found in central and southern areas, with zonal distributional features along the valley plain. And a large number of slightly or mildly disturbed areas are found in the north, middle and south

regions and there is a trend of slightly and mildly disturbed areas “encircling” extremely severe and severe areas(Figure7). The tendency of gradually "encircling" and "dispersing" severely and extremely disturbed areas demonstrates that human disturbance has had a positive effect on ecological restoration.

4. Conclusions

(1)The stronger the human disturbance is, the larger *PD* of corresponding landscape is, and vice versa and the stronger the human disturbance is, the larger *LPI* of corresponding landscape is, and vice versa. The change trend of *FN* and *SHDI* is consistent with that of human disturbance, while the change trend of *DI*, *CONNECT*, *CONTAG* and *SHEI* is opposite to that of human disturbance, indicating that the change of landscape pattern index is positively correlated with human disturbance.

(2) From 2008 to 2012, dominant efforts of human disturbance shift from severely disturbed areas to areas slightly disturbed. From 2013 to 2017, dominant efforts of human disturbance shift from extremely disturbed areas to moderately and slightly disturbed areas. The trends of the two human disturbance shifts are the same. Furthermore, bad landscape is gradually "encircled" and "dispersed" by good landscape, which indicates that human disturbance places positive effects on ecological restoration in earthquake-stricken areas during 2013 to 2017, and negative effects during 2012 to 2013.

References

- [1] Nassauer J I 1995 Culture and changing landscape structure [J] *Landscape Ecology* **10** 229-237
- [2] Turner M G 1989 Landscape Ecology:The effect of pattern on process[J] *Annual Review of Ecological System* **20(1)** 171-197
- [3] Wiens J 1989 A Spatial scaling in ecology [J] *Functional Ecology* **3(4)** 385-397
- [4] Wu Jianguo,Hobbs R 2002 Key issues and research priorities in landscape ecology:An idiosyncratic synthesis [J] *Landscape Ecology* **17(4)** 355-365
- [5] Fu Bojie,Chen Liding,Ma Keming,et al. 2011 The Principles and Application on Landscape Ecology [M] *Beijing:Science Press* (in Chinese)
- [6] Bürgi M, Anna M H, Schneeberger N 2004 Driving forces of landscape change:Current and new directions [J] *Landscape Ecology* **19(8)** 857-868
- [7] Hersperger A M, Bürgi M 2010 How do policies shape landscapes:Landscape change and its political driving forces in the limmat valley Switzerland 1930-2000[J] *Landscape Research* **35(3)** 259-279
- [8] Platt R H 2004 Land Use and Society [M] *Washington,D C:Island Press*
- [9] Thapa G B,Rasul G 2006 Implications of changing national policies on land use in the Chittagong Hill Tracts of Ban-gladesh[J] *Journal of Environmental Management* **81(4)** 441-453
- [10] Bi k I, Jelecek L, Setepanek V 2001 Land-use changes and their social driving forces in Czechia in the 19th and 20th centuries [J] *Land Use Policy* **18(1)** 65-73
- [11] Seabrook L, Mc Alpine C, Fensham R 2006 Cattle,crops and clearing: regional drivers of landscape change in the Bri-galow Belt,Queensland,Australia,1840-2004[J] *Landscape and Urban Planning* **78(4)** 373-385
- [12] Brandt J, Primdahl J, Reenberg A 1999 Rural land-use and dynamic forces analysis of driving forces in space and time//Koomen E, Bakeman A, Still-well J,et al. Land use Changes and Their Environmental Impact in Rural Areas in Europe [J] *Paris:UNESCO* 81-102
- [13] Hersperger A M,Bürgi M 2007 Driving forces of landscape change in the urbanizing Limmat Valley Switzerland //Koomen E,Bakeman A,Still-well J,et al. Modelling Land use Change[J] *Dordrecht:Springer* 45-60
- [14] Geist H J, Mc Connell W J, Lambin E F, et al. 2006 Causes and trajectories of land-use/cover change //Lambin E F,Geist H J. Land-use and Land Cover Change [J] *Berlin:Springer* 41-70
- [15] Koneff M D, Royle J A 2004 Modeling wetland change along theUnited States Atlantic Coast *Ecological Modelling* **177(1/2)** 41-59