Study on Desertification Monitoring in Tibet Qiang Pool National Nature Reserve based on MODIS Vegetation Index

Gong Zhao-hong[1] , Zhou wei-cai[2] , Du Yong[*3]
[1] Associate Professor, Plant Faculty of Science and Technology, Tibet Agricultural and Animal Husbandry College
No.8 Xueyuan Rd., Bayi, Nyingchi, 860000, Tibet;

[2] Intermediate Engineer, Beijing Digital View Technology Co., Ltd.
No.7 Kaituo Rd., Beijing 100085, China; Tel: +8610-84896208#881
E-mail: zhouwc@dview.com.cn

[3] Intermediate Engineer, Beijing Digital View Technology Co., Ltd.
No.7 Kaituo Rd., Beijing 100085, China; Tel: +86-15120074493
E-mail: xunri13@hotmail.com

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ABSTRACT: Taking Tibet Qiang Pool national nature reserve as example region, the paper used 10 years of MODIS satellite data to extract the vegetation thematic information; and then to research vegetation temporal variation characteristics through the normalized vegetation index NDVI on study area; Based on the results of the classification of NDVI, calculate the index of landscape pattern using FRAGSTATS software to analysis the pattern of research area. The results show that the number of patch increased significantly in the study area, the mean patch area reduces, patch density increases and the biggest patch index decreases.

1 Research Background

Desertification is the degradation of land in drylands. Caused by a variety of factors, such as climate change and human activities, desertification is one of the most significant global environmental problems[1]. Tibet Autonomous Region situated in the southwest of China with the area of 122, 00 sq km, is the main body of The Tibetan Plateau (also known as the Qinghai–Tibetan Plateau). Sometimes called 'the roof of the world'. The Qinghai-Tibetan Plateau has long been known as the natural geological museum, the golden key to the global organic mechanism, the natural laboratory for the continental dynamics theory, and the pulsar of the global changes, which are the important source region and the competition field deriving new theories, knowledge and discoveries.

According to the third national land desertification monitor (2004) results show that, Tibet is an important sandstorms source in China, and also one of the national desertification expansion of the three provinces, with the desertification area of 21.7 million sq km. Overall, it is still in less than destruction during treatment.

1.1 Research Status at Home and Abroad

Quantitative, high-spectral resolution satellite remote sensing can dramatically increase the accuracy of dryland monitoring. Hyperspectral imagery incorporated with field and laboratory data for analysis can be used to derive more quantitative and specific soil properties directly linked to soil degradation status, such as soil chemical properties, organic matter, mineralogical content, infiltration capacity, aggregation capacity, and runoff coefficient. According to a United Nations report (UNCCD, 2004) more than one billion people worldwide, most of them among the poorest in the world are affected by drought and desertification[2-5].

The occurrence of dust storms induced by wind erosion can be considered as an indicator of desertification[6].Recently, dust storms have also been an important environmental problem in East Asia. Batjargal et al. (2006) discussed the environmental degradation in Mongolia and the social, economic, and atmospheric impacts of dust storms in the sink areas[7]. The main dust sources over East Asia are the Taklimakan desert, the central Gobi desert, and the western part of inner-Mongolia plateau[8-10]. Xuan et al. (2000) found that springtime is the worst dust-emitting season over northern China[8]. Moreover, Xuan and Sokolik (2002) demonstrated that a combination of extreme aridity and strong winds is a key factor governing the dust emission there[9]. Despite the remote sensing data of spectral resolution, radiation resolution, time resolution and the spatial resolution continuously improve, but visual interpretation is still desertification and dynamic analysis of the main research method, and before the research contents of different is more widely, began to consider terrain ups and downs, desertification in valleys information classification, gradation and the role.

1.2 Methodologies

The NDVI is a commonly used vegetation index derived from remotely sensed measurements of electromagnetic energy in the red and near-infrared spectral regions. The concept of vegetation indices used to depict the large scale distribution and phonological changes of vegetation cover over particular is that green vegetation absorbs and reflects more radiance in the visible red and near infrared wavelength. Most spectral vegetation indices are based on a certain combination of the ration between the red waveband, R, where chlorophyll causes considerable absorption of incident light, and the NIR wavelengths, which corresponds to the zone of maximum reflectance of incoming radiation by healthy green leaves due to their internal mesophyll structure. NDVI utilizes differences in leaf absorptions in the red and near-infrared bands. The advantage of NDVI is that it has less influence from sun angle and illumination and provides relatively reliable information about vegetation cover dynamics. Therefore, we used NDVI to depict the desert cover areas and investigate the spatial distribution of green cover in East Asia. The NDVI is a normalized ratio of the NIR and red bands,

$$\mathrm{NDVI} = \frac{\rho\mathrm{NIR} - \rho\mathrm{red}}{\rho\mathrm{NIR} + \rho\mathrm{red}} \quad (1)$$

Where ρ_{NIR} and ρ_{red} are the surface bidirectional reflectance factors for their respective MODIS bands. This equation produces NDVI values which lie in the range of -1.0 to +1.0 with denser and/or healthier vegetation having higher positive values.

Desertification characteristic information spread over the original band, and coexisting with other non-desertification information staggered, it’s hard to identify to the complex features from single-band. The paper to be solved is the NDVI vegetation index and landscape pattern indices to the original combination of remote sensing image information fusion analysis, which takes into consideration due to the influence of terrain undulation.

2 The Generality of the Study Region

The area of interest-Tibet Qiang Pool national nature reserve located between79°42′-2°59′E and 32°10′-6°32′N, a total area of 29.8 million hectares, it is the largest natural reserve in China and the world 's second-largest reserve after Greenland national park. The reserve was established in 1993, April 4, 2000, the State Council approval to establish the promotion of national nature reserve. The main protection object is the complete, unique alpine ecosystems and multiple large ungulates. because of high altitude and abominable weather conditions, the vegetation and plants are extremely fragile over there, once damage ,they need a long time to recover or ever can't.

The research area is the core of the big Qiang Pool, the intensive district for wild animals, but also the typical area of the plateau desert ecosystem. vegetation type is simpler, the grassland vegetation and mainly for short Kobresia, small Kobresia, Caudate themeda,, It is concluded that there is a certain amount of plateau plant and Rare Plant such as Tamarisk、Saussurea resource distributing over there, but there is a trend of reduction in the amount. At present the seed plants found nearly 500 kinds. Because of the high altitude and bad weather conditions, the vegetation and the most fragile and plant once damage can't restore or take a long time to recover.

3 Data Gathering and Processing

The MODIS instruments have a wide swath and give a near global coverage in 1 to 2 days. It's a powerful resource satellite used to assess and monitoring the spatial patterns of land surface, functions of the environment and the interactions between the atmosphere, the ocean, and the biosphere. The MODIS instrument onboard the Terra satellite has been providing NDVI bi-weekly maximum composites over land since February 2000. The images from MODIS on board Terra were used in this study. Thus, the images of growing season were analyzed and the period was from September 2001 to September 2010.

The advantage of NDVI is that it has less influence from sun angle and illumination and provides relatively reliable information about vegetation cover dynamics. By comparing the historical data, NDVI value of the study area is divided into 8 levels after on-the-spot investigation: NDVI<=0, 0.05=>NDVI>0, 0.1=>NDVI>0.05, 0.15=>NDVI>0.1, 0.2=>NDVI>0.15, 0.25=>NDVI>0.2, 0.4=>NDVI>0.25 and NDVI>0.4. The figure 1-10 and table1 provided land cover types that will be used for comparison of desert cover distributions under 8 levels with those retrieved from satellite NDVI images during the period from year 2001 to year 2010.

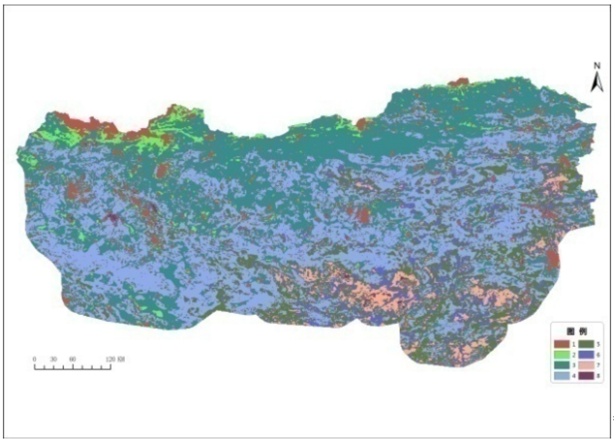

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Figure 1. NDVI classification image of 2001

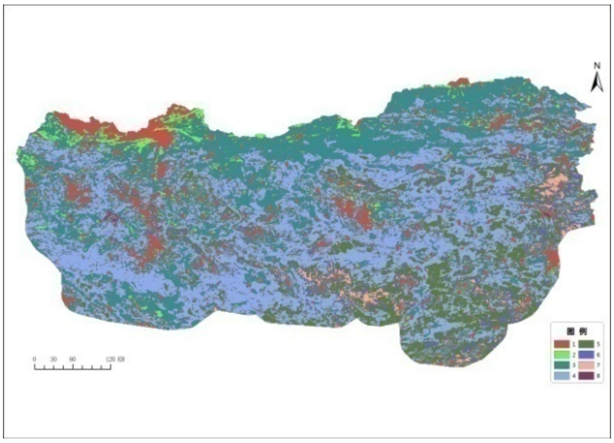

Figure 2. NDVI classification image of 2002

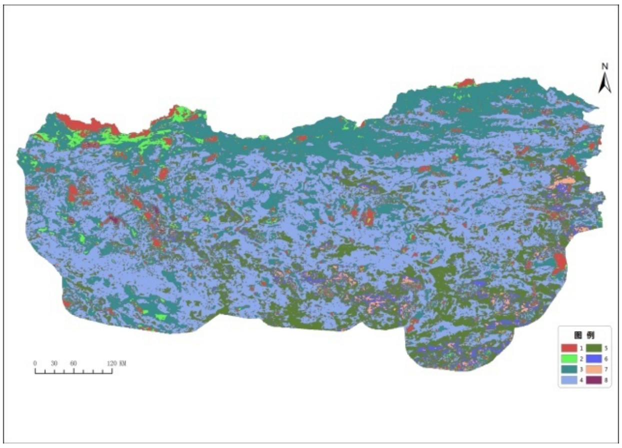

Figure 3. NDVI classification image of 2003

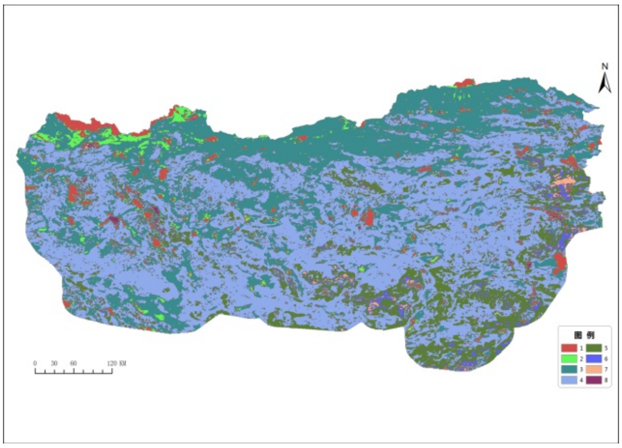

Figure 4. NDVI classification image of 2004

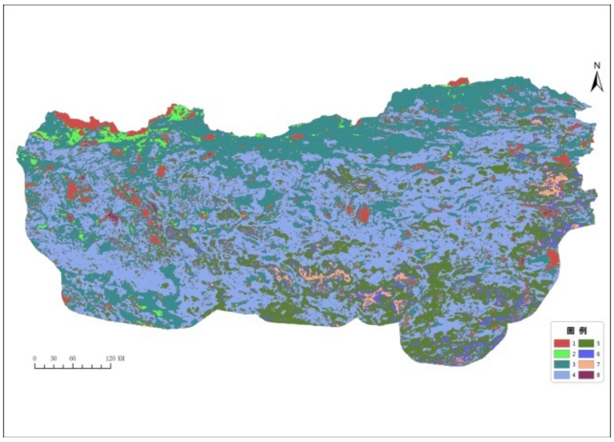

Figure 5. NDVI classification image of 2005

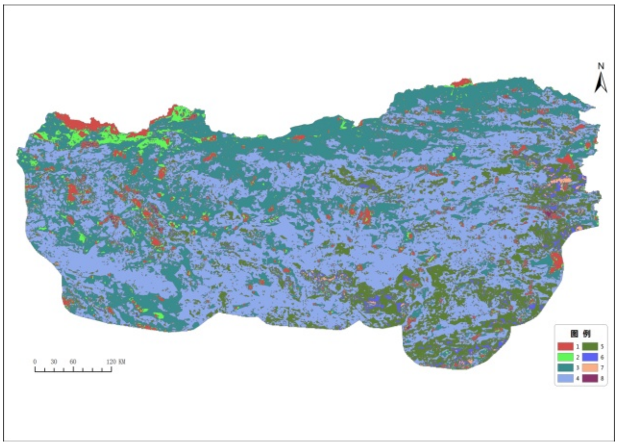

Figure 6. NDVI classification image of 2006

[*] The number 1、2、3、4、5、6、7、8 in the figure1-10 represent NDVI<=0、0.05=>NDVI>0、0.1=>NDVI>0.05、0.15=>NDVI>0.1、0.2=>NDVI>0.15、0.25=>NDVI>0.2、0.4=>NDVI>0.25、NDVI>0.4 respectively; The same as table1-10.

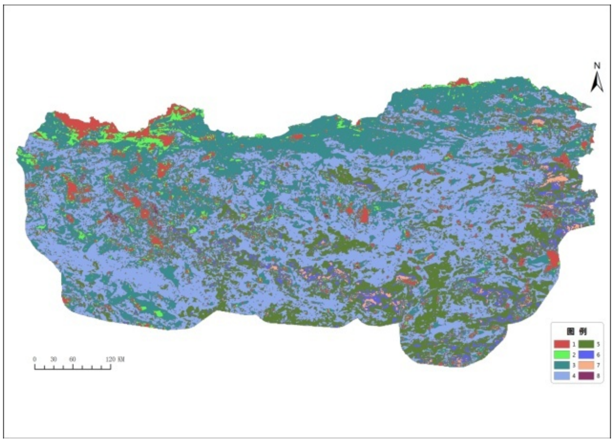

Figure 7. NDVI classification image of 2007

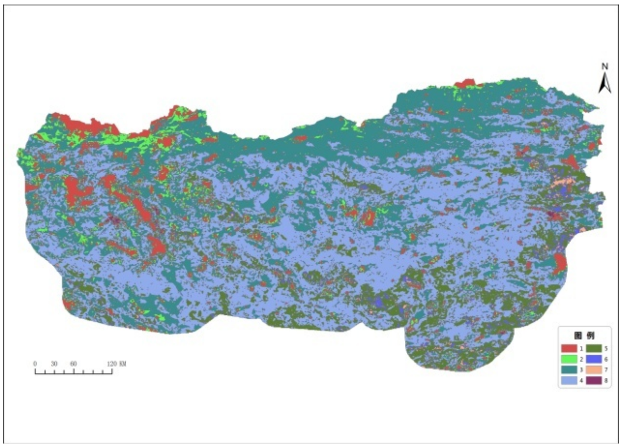

Figure 8. NDVI classification image of 2008

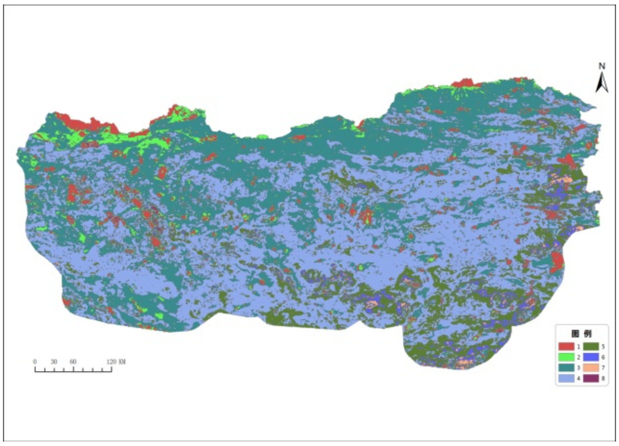

Figure 9. NDVI classification image of 2009

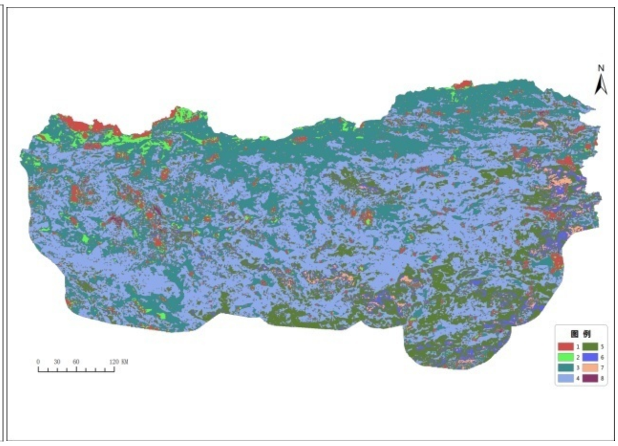

Figure 10. NDVI classification image of 2010

Table 1. NDVI statistic table during 2001 to 2010 (Unit：Km2)

Type / Year	1	2	3	4	5	6	7	8
2001a	12399.59	13370.94	87350.25	115829.20	36498.96	14656.61	11751.50	1075.61
2002a	20772.71	13212.49	77799.56	121037.97	43730.74	9751.19	5938.09	696.06
2003a	10809.12	9115.62	73744.01	139319.37	45386.38	9583.15	4292.77	689.08
2004a	9677.69	8156.47	82787.38	148355.23	35082.93	5824.17	2281.49	788.59
2005a	10768.01	8134.80	75070.02	135439.78	47831.38	10151.69	4730.14	814.99
2006a	11039.55	9656.93	87886.21	141787.74	34880.21	5357.95	1789.55	541.95
2007a	13858.28	11855.43	73650.19	130059.36	49076.46	10100.24	3640.64	699.03
2008a	17577.15	14458.87	84077.55	134377.85	34501.16	5308.73	1998.66	640.67
2009a	11413.06	11023.73	93144.66	135728.28	32161.17	6908.55	2104.65	454.99
2010a	10338.56	9145.12	80575.00	135490.85	42686.23	9666.08	4313.38	718.56

The vegetation can be seen in the study area is largely restored after the damage but the overall damage is greater than the recovery trend, especially in the NDVI > 0.25 on the interval is obvious, and in between 0.05 to 0.25, the study of vegetation remained at a relatively stable state.

4 Landscape Metrics

FRAGSTATS computes several simple statistics representing area and perimeter (or edge) at the patch, class, and landscape levels. In this paper, we used 4 representative indexes: Percentage of landscape (PLAND) is measures of landscape composition; specifically, how much of the landscape is comprised of a particular patch type. This is an important characteristic in a number of ecological applications. Number of patches (NP) and patch density (PD) of a particular habitat type may affect a variety of ecological processes, depending on the landscape context. Largest patch index (LPI) at the class level quantifies the percentage of total landscape area comprised by the largest patch[11]. As such, it is a simple measure of dominance.

$$PLAND = P_i = \frac{1}{A}\sum_{j=1} a_{ij}\,(100) \quad (2)$$

$$PD = \frac{1}{A} n_i (10{,}000)(100) \quad (3)$$

$$NP = n_i \quad (4)$$

$$LPI = \frac{1}{A}\max_{j=1}(a_{ij}) \times (100) \quad (5)$$

P_i = proportion of the landscape occupied by patch type i.

n_i = number of patches in the landscape of patch type i.

a_{ij} = area (m^2) of patch ij.

A = total landscape area (m^2).

Table 2. PLANDstatistic table during 2001 to 2010

Type / Year	1	2	3	4	5	6	7	8
2001a	3.5518	3.0847	27.4256	46.4182	14.5312	3.2828	1.4637	0.2421
2002a	3.9208	3.704	31.7677	46.4709	10.9131	2.3563	0.7152	0.1519
2003a	4.7432	4.0143	25.0709	44.5408	16.7504	3.4142	1.2266	0.2397
2004a	5.9458	5.1157	28.7554	45.4699	11.8954	1.889	0.7079	0.2208
2005a	3.789	3.2517	29.9715	48.5534	11.8283	1.8073	0.6131	0.1857
2006a	3.6585	2.8761	25.6797	45.8618	16.4683	3.554	1.619	0.2826
2007a	3.3049	2.7488	28.1923	50.8152	11.9234	1.9715	0.7729	0.2711
2008a	3.6948	3.0929	25.0535	47.7938	15.4224	3.2568	1.4485	0.2373
2009a	7.0561	4.651	26.605	40.9604	15.0399	3.4181	2.0303	0.2393
2010a	4.2487	4.4973	29.8167	39.6501	12.4141	4.9933	4.0094	0.3704

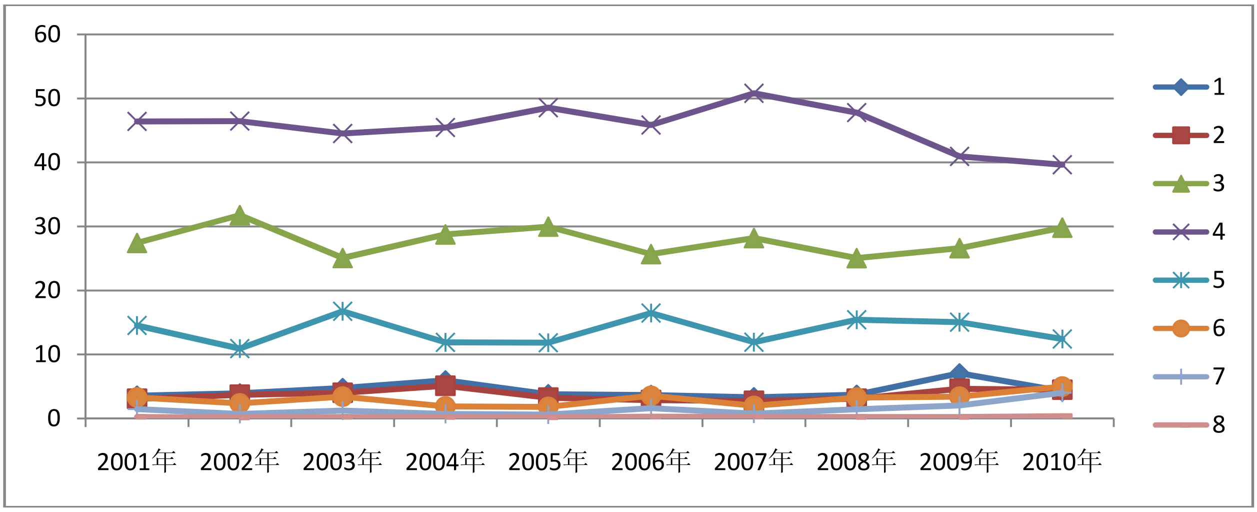

Figure 11. PLAND Change Trend during 2001 to 2010

Table 3. NP statistic table during 2001 to 2010

Type / Year	1	2	3	4	5	6	7	8
2001a	716	1754	2292	1586	2313	1463	829	228
2002a	696	1801	2001	1433	1742	922	547	186
2003a	931	2291	2470	1813	2321	1419	796	233
2004a	1127	3013	3543	2258	2768	1400	683	206
2005a	715	1780	2166	1434	1793	1016	520	164
2006a	726	1952	2814	1952	2687	1586	801	269

2007a	685	1531	2063	1283	1749	1021	645	230
2008a	751	1850	2410	1526	2226	1685	958	240
2009a	1416	3061	4127	2973	3618	2337	1080	278
2010a	790	1910	2124	1824	2827	2092	898	246

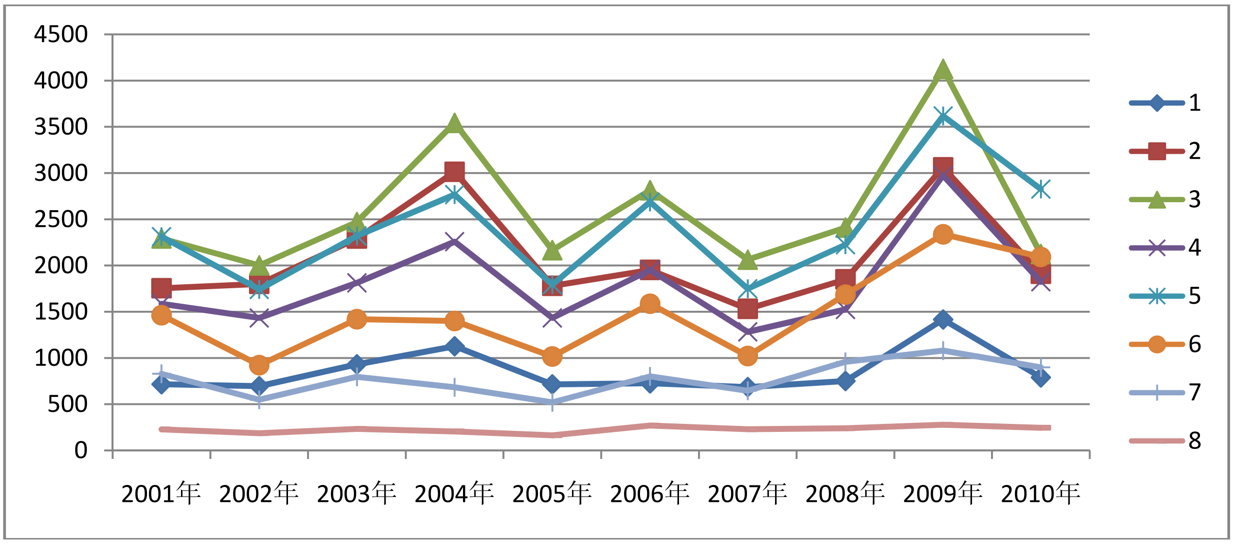

Figure 12. NP Change Trend during 2001 to 2010

Table 4. PD statistic table during 2001 to 2010

Type Year	1	2	3	4	5	6	7	8
2001a	0.0024	0.006	0.0078	0.0054	0.0079	0.005	0.0028	0.0008
2002a	0.0024	0.0061	0.0068	0.0049	0.0059	0.0031	0.0019	0.0006
2003a	0.0032	0.0078	0.0084	0.0062	0.0079	0.0048	0.0027	0.0008
2004a	0.0038	0.0103	0.0121	0.0077	0.0094	0.0048	0.0023	0.0007
2005a	0.0024	0.0061	0.0074	0.0049	0.0061	0.0035	0.0018	0.0006
2006a	0.0025	0.0067	0.0096	0.0067	0.0092	0.0054	0.0027	0.0009
2007a	0.0023	0.0052	0.007	0.0044	0.006	0.0035	0.0022	0.0008
2008a	0.0026	0.0063	0.0082	0.0052	0.0076	0.0058	0.0033	0.0008
2009a	0.0048	0.0104	0.0141	0.0101	0.0123	0.008	0.0037	0.0009
2010a	0.0027	0.0065	0.0073	0.0062	0.0097	0.0071	0.0031	0.0008

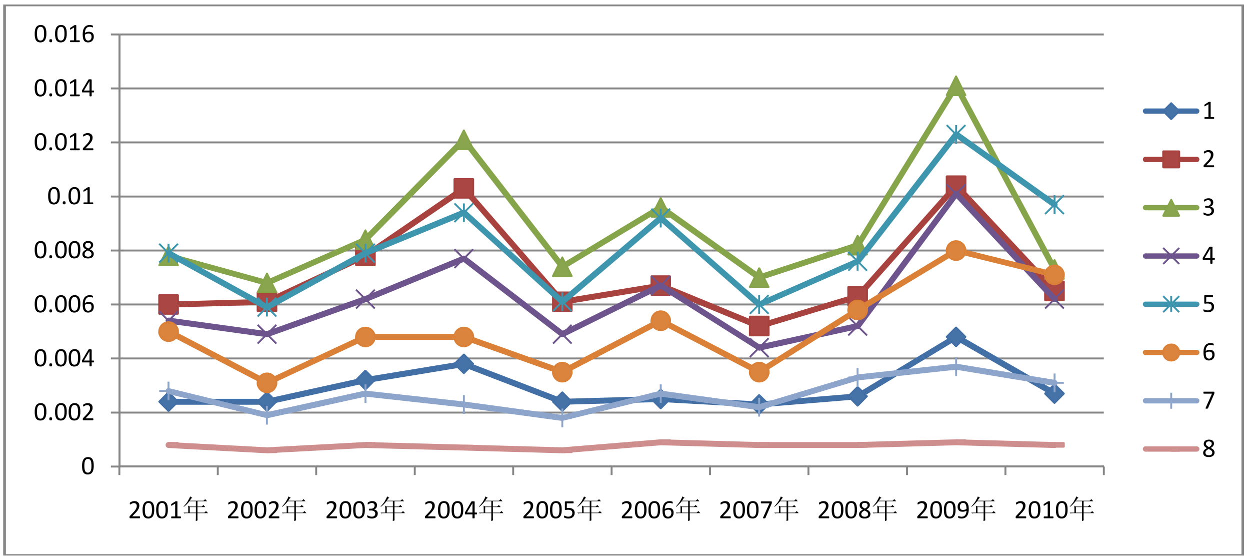

Figure 13. PD Change Trend during 2001 to 2010

Table 5. LPI statistic table during 2001 to 2010

Type Year	1	2	3	4	5	6	7	8
2001a	0.395	0.1557	14.3222	39.599	2.0495	0.1857	0.1489	0.0287
2002a	0.4175	0.3072	19.9523	34.8665	2.3324	0.1601	0.0587	0.016
2003a	0.5534	0.2376	12.9777	35.8331	3.4517	0.1417	0.1048	0.0256
2004a	0.5636	0.5574	15.343	36.8069	1.5756	0.0638	0.0993	0.0372
2005a	0.408	0.5189	16.3776	40.2984	1.3109	0.0591	0.0891	0.0311
2006a	0.4414	0.313	13.1969	38.1826	2.5167	0.126	0.2615	0.0348
2007a	0.4455	0.2844	16.2695	45.9099	2.5627	0.1089	0.1198	0.0365
2008a	0.4588	0.4609	12.7285	40.7773	3.2916	0.1205	0.1086	0.0331
2009a	1.4302	0.2004	12.3672	29.8411	2.36	0.0515	0.1925	0.0212
2010a	0.5316	0.5322	18.8133	30.5241	0.4394	0.1987	0.6773	0.0358

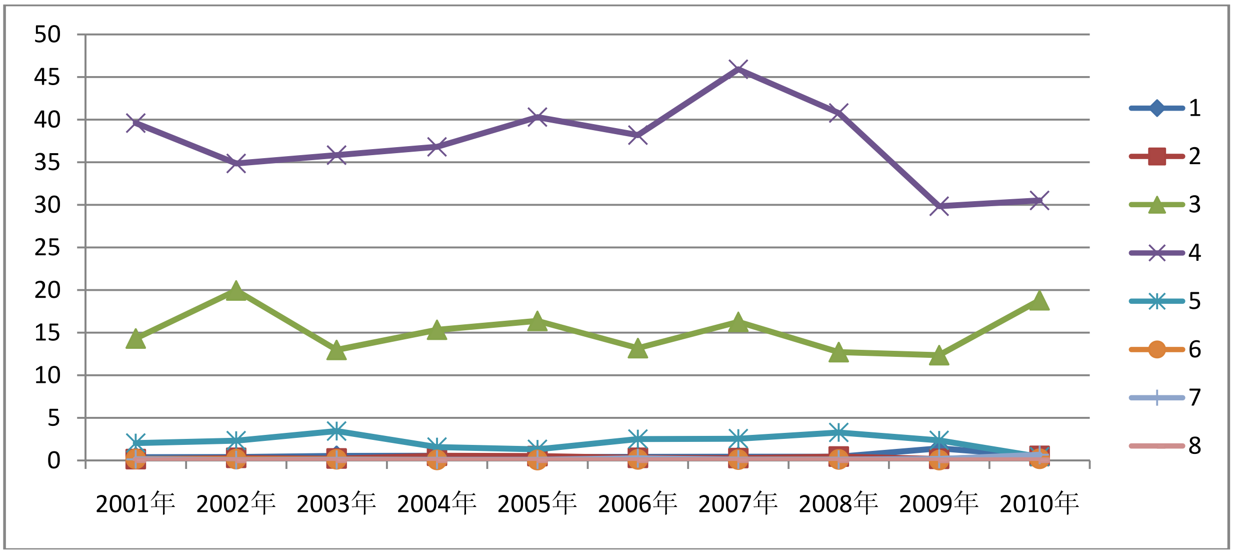

Figure 14. LPI Change Trend during 2001 to 2010

The results show that: ①The vegetation cover in the study area mainly by type 3.4.5, the percentage is greater than the 80%, and the overall tendency of type 4 is drops, but it could always achieve 40%.②The whole amount about patches was relatively increased, the average patch area decreased, and PD increased, resulting in an increase in landscape fragment degree. But the NP and PD of type 8 is in a stable state. ③The LPI of type 3 was rising slightly, the shape of patch trends to be complex. But type 4 was quite the contrary. ④From the landscape of view, the temporal of landscape patterns was significantly increased, the average patch area decreased, PD increased, and the LPI raised which indicated that landscape fragmentation increased gradually, with the landscape heterogeneity enhanced.

The grass in the study area was growing mostly sparse and scattered. Based on the investigation results from the Tibet Autonomous Region Forestry Bureau, the increasing wildlife was a burden on the grassland, especially the Equus kiang was a great destructive power in grassland.

5 Conclusions

5.1 Conclusions

Landscape pattern indices are introduced in this paper, from the landscape level, we analysis the dynamic changes of desertification, because of a variety of natural reasons and human activity, it caused the increase of landscape fragmentation and enhanced the heterogeneity of landscape. This paper used multiple level classification method and comprehensive analysis was made on the PLAND, NP, PD and LPI four landscape index factors, according to the composite index, determine the extent of grassland desertification.

5.2 Discussion and Prospect

Ground survey data cannot be used for information extraction from the historical data in this paper, so the precision of information extraction can only be tested through relative literature data. Secondly, in recent years, scholars at home and abroad have made lots of experimental study and analysis and accumulated abundant experiences in desertification monitoring and assessment. However, some methods still remain to be studied and solved. Desertification monitoring and assessment methods are not mature; the problem is the lack of comparability and veracity due to the disaccord of test method. Therefore establishing a set of systematic and scientific evaluation index and standard for suitable to local condition is a problem for monitoring and assessment, but now we need to keep explore and improve based on present fertilization level.

References

[1] Hill, J., 2004. "Remote Sensing in Desertification Research". University of Trier, Germany, 6 p.

[2] Hoffman, T., 2002. "Remote Sensing Methodologies Used for Assessment of Desertification in Southern Africa". Capetown Symposium on Desertification in South Africa, 13 p.

[3] Ilaiwi, M., 1999. "Modern Techniques for Desertification Monitoring and Combating in the Syrian Steppe". Proceedings of the 3rd Conference on Desertification and Environmental Studies, 30 Nov. – 4 Dec., 1999, Riyadh, Saudi Arabia, pp. 399-415.

[4] Larsson, H., 2002. "Analysis in Variation in Land Cover between 1972 and 1990, Kassala Province, Eastern Sudan, Using Landsat MSS Data". International Journal of Remote Sensing, vol. 23, No. 2, pp. 325-333.

[5] Pacheco, R.A., 1980. "Applications of Remote Sensing to Agricultural Development in Tropical Countries". In Remote Sensing Application in Agriculture and Hydrology, ed. George, F., pp. 309-325.

[6] J. Xu, "Sand-dust storms in and around the Ordos Plateau of China as influenced by land use change and desertification," CATENA, 65, 3, 279-284 (2006).

[7] Z. Batjargal, J. Dulam and Y.S. Chung, "Dust storms are an indication of an unhealthy environment in East Asia,"nEnvironmental Monitoring and Assessment, 114, 1-3, 447 (2006).

[8] J. Xuan, G. Liu and K. Du, "Dust emission inventory in Northern China," Atmospheric Environment, 34, 26, 4565-4570 (2000).

[9] Z. Song, "A numerical simulation of dust storms in China," Environmental Modeling & Software, 19, 2, 141-151 (2004).

[10] B. Laurent, B. Marticorena, G. Bergametti and F. Mei, "Modeling mineral dust emissions from Chinese and Mongolian deserts," Global and Planetary Change, 52, 1-4, 121-141 (2006).

[11] McGarigal, K., S. A. Cushman, M. C. Neel, and E.Ene. 2002. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst. Available at the following web site: http://www.umass.edu/landeco/research/fragstats/fragstats.html