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Aeolian Desertification in Northern China

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Abstract: Aeolian desertification is land degradation through wind erosion mainly caused by excessive human activities in arid, semiarid and part of sub-humid regions in Northern China. To compare the analyses, results of remote sensing data in late 1950, 1975, 1987, 2000 and 2010 was conducted. We can summarize that the development of aeolian desertified land in Northern China has been accelerated for the last 5 decades, as its annual expanded rate was 1,560 km^2 between 1950 and 1975, 2,100 km^2 between 1975 and 1988, 3,600 km^2 from 1988 to 2000 and -1375 km^2 from 2000 to 2010. The whole situation of desertification was depraved before 2000 and was improved after 2000. China has made much progress in understanding and combating aeolian desertification through many efforts and projects for decades. One such project is the National Project of Grain for Green Program and 1060 counties in 22 provinces have been included in this project. The objective is to reclaim 3.67 million ha of land farming and degraded steppe, and 5.13 million ha of aeolian desertified land suited to reforestation and vegetation will be rehabilitated. There are about 8 million ha of lands under the threats of aeolian desertification that will be brought under control in the next ten years and about 26.67 million ha of windbreaks will be planted. This paper is intended to analyze the process of aeolian desertification and to introduce the idea and method for combating aeolian desertification in Northern China.

Key Words: Aeolian desertification, Landuse, Northern China, Policy and measure

1. Introduction

Desertification and land degradation is a very serious environment and socio-economic problem facing the world today. According to the UNCCD and many research results in China, desertification can be classified into several major types, namely aeolian desertification (wind erosion), soil-water erosion and salinization, etc. One of the main manifestations of desertification in Northern China is aeolian desertification. Since the 1950s scientists in China have conducted a series of researches on natural conditions, resources, sand movement, wind erosion and its control on farmlands and grasslands, and rational use of water and land resources in desert and desertified regions. These research efforts and technique popularization works established a solid basis for launching large-scale land desertification studies in Northern China (Zhu *et al.*, 1980; Zhu and Liu, 1989; Zhu and Wang, 1992; Wang and Zhu, 2001; Wang, 2011). Through remote sensing monitoring, field investigation and statistical analysis, we found that from 1950s to 1970s aeolian desertification in Northern China developed at an annual rate of 1560 km^2, of which aeolian desertified land occupied 33.4×10^4 km^2 (Zhu and Wang, 1990).

The research and practices in land degradation of regions in Northern China over the past 30 years defined the aeolian desertification as land degradation characterized by wind erosion mainly resulting from the excessive human activities in arid, semiarid and part of sub-humid regions in Northern China. In this respect, the man-land relation and their interaction must be stressed, *i.e.* only the land degradation resulted from the adverse effects of human activities and the interaction of wind-dominated external agents is called aeolian desertification. In fact, the human impact on aeolian desertification is much more significant compared to natural causes. The process of aeolian desertification is primarily caused by changes of the landuse from rangeland to farmland and increase of landuse intensity (over-cultivation, over-grassing and over-fuelwood collection). The landcover/vegetation has been destroyed by human activities that have accelerated the development of aeolian desertification.

2. Monitoring of Aeolian Desertification from 1975 to 2010 in Northern China

Because aeolian desertification is a gradual process of land degradation, satellite image data is a useful tool for monitoring this process over long periods in large areas, particularly when combined with field investigation and verification. To further determine the modern development of desertification in northern China, we used Landsat MSS images mainly acquired from 1975, Landsat TM images mainly acquired from 1990, 2005 and 2010, and Landsat ETM images mainly acquired from 2000 to derive the desertified land databases; the actual image choice and year depended on the availability of suitable Landsat image data (e.g., cloud-free images). By overlaying

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Table 1. Changes in aeolian desertified land in Northern China from 1975 to 2010 (km^2).

Decade	1975s	1990s	1975—1990s		2000s	1990s-2000s		2005s	2000-2005s		2010s	2005-2010s		1975-2010s	
			Change	Annual change		Change	Annual change		Change	Annual change		Change	Annual change	Change	Annual change
Beijing	11.53	11.8	0.28	0.02	10.95	-0.85	-0.09	8.06	-2.89	-0.58	3.62	-4.44	-0.89	-7.91	-0.23
Tianjin	4.98	4.98	0	0	5.25	0.27	0.03	5.21	-0.05	-0.01	3.35	-1.85	-0.37	-1.63	-0.05
Hebei	1728.39	1978.98	250.59	16.71	2076.85	97.87	9.79	1991.32	-85.53	-17.11	1777.64	-213.68	-42.74	49.25	1.41
Shanxi	37.17	44.71	7.54	0.5	50.51	5.8	0.58	20.39	-30.12	-6.02	10.83	-9.56	-1.91	-26.34	-0.75
Inner Mongolia	201153.92	227235.14	26081.22	1738.75	256661.66	29426.52	2942.65	253048.93	-3612.73	-722.55	250949.11	-2099.83	-419.97	49795.19	1422.72
Liaoning	194.25	358.56	164.31	10.95	798.44	439.88	43.99	799.32	0.87	0.17	779.89	-19.43	-3.89	585.64	16.73
Jilin	6088.88	7537.97	1449.09	96.61	9117.06	1579.08	157.91	8898.53	-218.53	-43.71	8770.1	-128.42	-25.68	2681.22	76.61
Heilongjiang	3607.09	4929.67	1322.59	88.17	6575.62	1645.95	164.59	5012.01	-1563.61	-312.72	4659.18	-352.83	-70.57	1052.09	30.06
Shandong	572.21	517.4	-54.81	-3.65	417.75	-99.65	-9.97	223.38	-194.37	-38.87	65.41	-157.97	-31.59	-506.8	-14.48
Henan	301.63	70.34	-231.3	-15.42	65.7	-4.63	-0.46	59.39	-6.32	-1.26	12.15	-47.24	-9.45	-289.48	-8.27
Sichuan	278.33	378.09	99.76	6.65	534.56	156.47	15.65	360.1	-174.45	-34.89	264.39	-95.72	-19.14	-13.94	-0.4
Shaanxi	11741.02	11848.01	107	7.13	11943.06	95.05	9.5	11666.93	-276.13	-55.23	11259.89	-407.04	-81.41	-481.13	-13.75
Gansu	12050.8	12412.2	361.4	24.09	12058.52	-353.68	-35.37	11848.7	-209.82	-41.96	11679.44	-169.25	-33.85	-371.36	-10.61
Qinghai	31214.18	33020.95	1806.77	120.45	35458.26	2437.31	243.73	34805.62	-652.64	-130.53	33265.12	-1540.49	-308.1	2050.94	58.6
Ningxia	4683.84	4933.3	249.46	16.63	4855.89	-77.41	-7.74	4722.34	-133.55	-26.71	4602.64	-119.7	-23.94	-81.2	-2.32
Xinjiang	47762.22	49986.65	2224.43	148.3	49053.58	-933.07	-93.31	48037.04	-1016.53	-203.31	47832.72	-204.32	-40.86	70.51	2.01
Total	321430.44	355268.75	33838.32	2255.89	389683.67	34414.91	3441.49	381507.25	-8176.42	-1635.28	375935.48	-5571.77	-1114.35	54505.05	1557.29

data from consecutive years, we obtained databases of the dynamics of desertification from 1975 to 1990, 1990 to 2000, 2000 to 2005 and 2005 to 2010.

We found that from 1975 to 1990, the area of aeolian adesertification increased about 3.39×10^4 km^2, from 33.4×10^4 km^2 to 35.53×10^4 km^2 and at an average annual rate of 0.23×10^4 km^2. From 1990 to 2000 aeolian adesertification increased to 38.97×10^4 km^2, representing an increase of 3.44×10^4 km^2 and an average annual increase of 0.34×10^4 km^2. From 2000 to 2005 the area of aiolian desertified land decreased about 0.82×10^4 km^2 (so the total area reached to 38.15×10^4 km^2) and decreased at an average annual rate of 0.16×10^4 km^2. From 2005 to 2010, the area continued to decrease, reached to 37.59×10^4 km^2 (decrease of 0.56×10^4 km^2), at an average annual rate of 0.11×10^4 km^2 (**Table 1**).

3. Combating Aeolian Desertification in Northern China

China made a lot of progresses in understanding and combating the process of aeolian desertification through many efforts since the 1950's and has invested in several projects. According to the natural and economic conditions of arid and semiarid regions and the processes of aeolian desertification in China as well as some typical experiences and models, combating aeolian desertification should consider thoroughly the ecological, economic and social benefits, and should also follow the ecological principles of moderate utilization and multi-complementation to contain landuse (Wang, 2004). In order to improve the ecosystem of the whole arid and semiarid regions we should work to develop a comprehensive plan and adopt a long-term strategy to combat desertification. Specifically regarding economic development, farmers should be encouraged to adopt the principle of diversified production dominated by forestry. In the meanwhile population growth should be effectively controlled. The arrangement of desertification combating projects can be divided into three key steps: research organizations mainly undertake aeolian desertification controlled studies in the experimental plots; research organizations in cooperation with production departments conduct experiments in the demonstration plots; production departments and local people popularize successful techniques. In the mixed farming-grazing region where the distribution of residential areas, cropland and grassland is scattered, with ecological household as an unit such measures as prohibiting grazing, readjusting rainfed farming-dominated landuse structure, increasing forest and grassland area, intensive management to the land with better water and fertility conditions, establishing farmland forest net and patchy forest (shrub) in interdune depressions are adopted to control aeolian desertification spread. This will also contribute to economic development. In the grazing grasslands a rational stocking rate and rotational grazing system should be established. In addition, efforts should be made to construct artificial grassland and forage base, strategically arrange drinking water wells, define grazing density and build roads. In the arid zone, a comprehensive plan should be developed with basin as an ecological unit, to formulate a strategic water allocation plan, construct farmland forest nets inside oases and sandbreak tree-shrub belt around the oases. These efforts, in combination with mechanical fence and sand-fixing plants inside fences grids, will form a perfect protective system. In addition, the transport lines in the dense sand dune regions should be protected by mechanical sand fences and sand-fixing plants, with emphasis on fixation in combination with block.

Since 2000, the central government has invested total of 217.22 billion Chinese Yuan, and had implemented a series of ecological construction projects, focusing on natural resources conservation, returning farmland to woodland or grassland forest, sandstorm source control surrounding Beijing and Tianjin Area, construction of Three-North Shelterbelt System, wildlife protection and nature reserve construction, wetland

protection and restoration, etc. These projects greatly accelerated the western region's ecological protection and construction process. According to the announcement of China's State Forestry Administration, the forest coverage in the western region in 2008 had increased by 6.7% and reached to 17% compared with 10 years ago. After implementation of the western development strategy in the last 10 years, 30.65 million ha of planted forests have been added to the western region. As the seventh national forest resources inventory data issued in 2011, forest reserves in the western region amounted to 8.27 billion cubic meters, compared with the fifth inventory10 years ago, and increased by nearly 1.3 billion cubic meters. The increase of forest cover effectively controlled soil erosion and aeolian desertification. Shaanxi, Gansu, Ningxia, Inner Mongolia and other provinces across the country were the first to achieve the historic change from the "sand advances and human retreating" to the "human advancing and sand retreating". In Mu Us Sandy Land, the local government and people had achieved a new phase of control and use of the aeolian desertified land. About 0.15 million km^2 of soil erosion on the Loess Plateau were controlled and annual silt and sand sediment into the Yellow River was reduced by more than 300 million tons.

The biggest National Project is the "Grain for Green Program" (1997-2012) which included 1060 counties in 22 provinces. The objective was to withdraw 3.67 million ha of dry land farming and degraded steppe and to rehabilitate 5.13 million ha of aeolian desertified land suited to reforestation and revegetation. There are about 8 million ha of lands under the threat of aeolian desertification that will be brought under control in the next 10 years and 26.67 million ha of windbreaks will be planted. The total financial input is estimated at 75 billion Yuan (11 billion US$) provided entirely from the central Chinese government. Thanks to many efforts from centre and local governments, local people in the aeolian desertified regions for many years, aeolian desertification has been reversed distinctly. In fact, aeolian desertification has decreased 1280 km^2 annually during last 10 years.

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