Response of Eco-environmental Security to Land Use/cover Changes and Adjustment of Land Use Policy and Pattern in China*

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Abstract: Since the late 1970s, reform and opening-up policy has been implemented in China, which brought in a great deal of foreign investment and the availability of the transition of land usufruct in both rural and urban areas. This leads to repaid urbanization and fast economic development, with an increase rate of 15% in urbanization level, an increase ratio of 2% in the urban district area and over 9% GDP growth per year. Relatively, serious eco-environment disasters occurred, such as the pollution accident in Huaihe River in 1994, the lower reaches of Yellow River drying up for 227 days in 1997, the unusual big floods in Yangtze River and Nengjiang River in 1998, the 12 dust storm events in North China which affected Beijing, Korea, and Japan in 2000, and the serious pollution accident in Huaihe River again in 2004. Integrated analysis shows that, it is mainly caused by the land use/ cover changes, the accelerating urbanization, and the rapid growth of village enterprises. The case studies in China find out that, it is very important to plan land use/cover pattern under eco-environmental security and adjust national policy of land use and environmental management friendly to ecosystem, which is not only beneficial to improve ecosystem health and environmental quality and advance sustainable development of China, but also helpful to maintain the ecosystem health in Asia and the whole world.

Keywords: land use/ cover change, eco-environment security, land use policy and planning adjustment, China

In the International Human Dimension Programs (IHDP) of Global Environment Change research, the eco-environmental effect of land use/cover change has been paid wildly attention. And the existing research shows that land use/cover change not only influences the earth-surface physical parameters, but also deeply influences the earth-surface nitrogen reserves and its spacial distribution, which leads to the impact on the global climate change, especially the global warming process and speed (Steffen W. et al., 1999). The main driving force of land use/cover change comes from human, especially the population expansion, the urbanization acceleration and the economic development and social system transform (Turner B.L.Ⅱ. et al., 1995). The wildly applications of new technology, especially the industrial technology development, has also become one important reason of land use/cover change. In a way, the transform of society and economy and regimes determines the utilizing efficiency and benefit of land system radically. The Global Land Program (GLP) formed from IGBP and IHDP, aims to conform LUCC and GCTE as integration (Ojima D. et al., 2004), which focuses on the geo-biochemical process and its influence mechanism on ecosystem serving function, etc. Based on some case study analysis of the eco-environment effect of land use/cover change, this paper sums up the repaid urbanization and fast economic development process, and the corresponding serious eco-environmental disaster situation in the recent over 50 years, since the reform and opening-up policy implementation in China. Through temporal and spacial pattern paralleled analysis, the influence

* This work is supported by a grant from National Science Fund for Distinguished Young Scholars （No. 40425008）
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mechanism of human activity especially land use/cover change on eco-environment is revealed and some policy suggestion is put forward to improve the influence mechanism and adjust the focused field construction of GLP.

1. Land use/cover change reconstruction in China

China is a country with a large area proportion of mountains and hills and is deeply influenced by monsoon climate. According to statistics, the area proportions of mountain region, hill region, plateau region, plain region and basin region in the whole country respectively are 33.3%, 9.90%, 26.04%, 11.98% and 18.75% (National Bureau of Statistics of China, 1991). The wide eastern area of China is influenced by the south-east monsoon, and the precipitation is mainly concentrated in June, July and August, which is over 70% of precipitation in the whole year; The winter monsoon covers the most part of China when it's strong. The southeast coastal districts of China is influenced by typhoon disasters frequently and there are 6-7 typhoons landing every year, even 10 in frequent years; The wide northwest district, the north China, and the northeast district of China are all deeply influenced by cold wave in winter, and endure 3-5 dust storms per year, even more than 10 in frequent years; The Qingzang plateau of an altitude over 3000m is influenced by plateau monsoon, and also has a warming tendency in the recent years, because the plateau ozone is becoming thinner and thinner. This warming phenomenon disturbs the ecosystem development seriously and leads to the frozen earth melting and lake reduction. In China, the land area proportions in the tropic zone, the sub-tropic zone, the warm-temperate zone, the temperate zone and the cold-temperate zone respectively are 1.7%, 25.7%, 19.2%, 26.3%, 1.2% and 25.9%; And the land area proportions in the wet zone, the semi-wet zone, the semi-arid zone and the arid zone respectively are 32.0%, 15.0%, 22.0% and 31.0% (Wu Chuanjun, 1994). Under the above impact of regional climate difference, severe human activities make land use/cover change more complicated and cause significant changes in China.

To come back and reconstruct the land use/cover change of China needs a great deal of practical work. Restricted by available materials and documents, this paper only discusses about the changes of farmland, forestland, grassland, wetland, construction land and unutilized land since 1949.

1.1 Farmland changes

With a range of historical records and literature, Zhao Songqiao reverted and rebuilt the expansion of agriculture development zones in China (Zhao Songqiao, 1994). In which, since 11century BC, agriculture development has expanded to the north, the south and the west centering on the middle plain area of Yellow River Basin. In the end of 19 century, nearly half of the area of China has been exploited. The land use pattern has changed into agricultural land coverage with different products or mixed land coverage with agricultural land and secondary forests from original natural land coverage in different climate zones. According to the initial statistics, the proportion of farmland to the whole area has been 10.2% from the 0.63% in 221 BC; 64.15% of the whole area has been occupied by different kinds of agricultural land. In detail, the proportion of farmland is 10.20%, garden plots 0.34%, forestland 13.02% (in which, Forested land is 8.63%), pastures 40.83% (in which, the utilized pasture ratio is 27.78% in 1949).

According to data of National Bureau of Statistics of China, the area of farmland in China is still in a fluctuating increase from 1949 to the middle of 1950s. In 1956 and 1957, the area of farmland reached the peak: 1,118,000 km^2, 11.7% of the whole country area. Since then, the area of farmland has begun decreasing in a fluctuation. In 1996, the area of farmland is 949,000km^2, 9.9% of the whole country area. However, because the statistics data are limited by local statistical technologies and affected by agricultural tax regulation, even for displaying the agricultural achievement, several

sections and researchers didn't agree with the opinion of decreasing in a fluctuation since 1957. Based on the survey data of the Ministry of Land and Resources P.R.C. (namely, the land investigation data), the farmland area was 1,300,300km^2 in the whole country and the corresponding proportion was 13.55% until the end of 1996 (Department of Planning in the National Bureau of Statistics of China, 1994). This number is 351,300km^2 higher than statistical number at the same period, namely 3.65% of the whole country area. Meanwhile, several scientific research institutes also surveyed the Chinese farmland using remote sensing and gained the data (Chen, et al, 2003). Among these results, the result of the Integrated Investigation Committee of CAS (Chinese Academy of Science) is: 1,356,000km^2 of farmland and 14.13% of the whole country area. The result of Institute of Geographical Sciences and Natural Resources Research, CAS (Chinese Academy of Science) is: 1,364,000km^2 of farmland and 14.21% of the total country area (surveyed in the end of 1980s). Since 2001, the Ministry of Land and Resources P.R.C. has begun promulgating the information of farmland in the Bulletin of China's Land Resources each year. And it's found out that, from 2001 to 2004, the area of farmland respectively is 1,276,000km^2, 1,259,300km^2, 1,253,900km^2 and 1,224,400 km^2 and the corresponding ratio of the whole country area is 13.29%, 13.12%, 13.06% and 12.75%. Therefore, a conclusion is made that the area of farmland in China has increased from the ratio of 10.2% in 1949 (if the area in 1949 can be compared) to the 14.13% in the end of 1980s. After reaching the peak, it began reducing since the beginning of 1990s. In 1996, the ratio is 13.55%; in 2004, it's 12.75%. Then, it's not accurate of the original conclusion that the area of farmland has reduced since reaching the peak in the end of 1950s. In fact, it reached the peak in the end of 1980s and then began reducing with fluctuation. So the date of peak has been postponed for 30 years. This result is meaningful to well explain the severe conditions of ecological environment security in China and the occurrence of a series of ecological disasters since the 1990s.

1.2 Forestland changes

According to the data of National Bureau of Statistics of China, the area of forestland was 1,250,000 km^2 in 1949, 13.02% of the total country area. Among this forestland, there was 828,000km^2 forested land with the crown density larger than 0.3, and its ratio to the whole country area is 8.63%. In 1990, the corresponding data was 1,954,000 km^2 and 1,240,000 km^2, while the ratio of the whole country area was 20.35% and 12.99%. Based on the Forest Census Data of State Forestry Administration, P. R.C (about once in five years), there was 1,200,000 km^2 forestland in the middle of 1970s, 1,150,000 km^2 in the end of 1970s, 1,190,000 km^2 in the middle of 1980s, 1,250,000 km^2 in the end of 1980s, 1,350,000 km^2 in the middle of 1990s, 1,590,000 km^2 in the end of 1990s, 1,750,000 km^2 in the beginning of 2000s. And the corresponding ratio was 12.70%, 12.00%, 12.36%, 12.98%, 13.92%, 16.55% and 18.21%. Since the end of 1980s, Chinese Government has executed the construction of the project of "three-north" (North China, Northeast and Northwest) shelter belt system of China for 70 years. And the first period of the project has begun in the beginning of 1980s, which results in an increase of forest cover ratio mainly. It can be concluded that it takes nearly 20 years for the ratio of forest cover in the whole country returning to the level in the middle of 1970s. In detail, if the data in 1949 (8.67%) can be compared, the forest cover began increasing since 1949, and reached 12.7% in 1975, then it decreased, and returned to 12.98% in 1995.

1.3 Wetland changes

The statistics information about wetland has been paid more attention in recent years, which was once described as water area only. Since joining in the Convention for the World Wetland Protection, in

order to protect wetland and alleviate the flood disaster and non-point pollution, the government has paid much attention to survey and do study on wetland, and began to take relevant measures, such as returning embankment to lake, returning farmland to shoal land, and so on. According to the data from National Bureau of Statistics of China, the water area in whole country was 225,000 km^2 in 1949 and its ratio to the whole country area was 2.35%. In 1990, the water area was 341,000 km^2 and its ratio to the whole country area was 3.55%. Moreover, according to the surveying results of Institute of Geographical Sciences and Natural Resources Research, CAS (Chinese Academy of Science), around 1990, the area of water and wetland was 347,000 km^2, with a ratio to the whole country area of 3.62% (it's little higher than the one of National Bureau of Statistics of China, mainly for including the area of seashore and shoal land). In 1996, the investigation on land use actuality in the whole country shows that, in 1996, the water area was about 384,000 km^2, and the ratio to the whole country area was 4.00%. In 2001, the Bulletin of China's Land Resources of the Ministry of Land and Resources P. R.C. promulgated the water area was about 220,000 km^2 (in which, the area of water conservancy such as reservoirs was 57,000 km^2), with a ratio to the whole country area of 2.29%. Hence, a conclusion can been drawn that the area of wetland and water was still reducing wholly with an increase partly though effective policies of "returning embankment to lake" and protecting shoal land have been executed since the Yangtze River flood in 1998. This is an important reason for the increasing flood disasters in recent years.

1.4 Grassland changes

With the expansion of desertification in north China recently, people began to pay attention to the changes of grassland area. However, restricted by the understanding, recognition and measuring technology of grassland and pasture areas, we can only know roughly about its change. Based on the data of National Bureau of Statistics of China, in 1949 the area of pasture in the whole country was about 3,912,000 km^2 and the ratio to the whole country area was 40.83%. Among this grassland area, the area of utilized grassland was 267,000 km^2, whose ratio to the whole country area was 27.78%. And according to Institute of Geographical Sciences and Natural Resources Research, CAS (Chinese Academy of Science), in 1990 the area of pasturing land was 3,386,000 km^2 and the ratio to the whole country area is 35.28%. Among which, the area of used grassland is 224,000 km^2 and the ratio to the whole country area is 23.37%. Moreover, according to the agricultural statistical data, in 1949 the area of total pastures was 2,667,000 km^2 and the ratio to the whole country area was 27.78%. And the survey result of land use status quo in the whole country shows that, in 1996 the area of total pastures was 2,661,000 km^2 and the ratio to the whole country area was 27.72%. These show that the change of total pasturing area isn't obvious in the recent 50 years. With the data in the Bulletin of China's Land Resources of the Ministry of Land and Resources P.R.C, it can be found out that, from 2001 to 2004, the area of pasturing land respectively was 2,639,000 km^2, 2,635,000km^2, 2,631,000km^2 and 2,627,000 km^2, and the corresponding ratio to the whole country area respectively was 27.49%, 27.45%, 27.41% and 27.35%. Therefore, the area of pasturing land in China changes little while the quality of pasturing land; especially the natural pasturing land changes lots. And according to the investigation on grassland in Inner Mongolia (Zhang, et al, 1990), the height, coverage and yield of grass decreased obviously.

1.5 Construction land changes

The construction land is increasing quickly in recent years, and a large quantity of agricultural land has been expropriated for construction, with the development of urbanization and the national key projects construction (such as railways, airports, ports and son on). According to the data from Chen

Baiming (Chen Baiming, 2003), the urban and rural dwelling land area was 47,300 km^2 in 1949 and 240,700 km^2 in 1996, namely the area increased more than 5 times in the recent 50 years. The transportation land in 1949 and 1996 was respectively 20,000 km^2 and 54,6000 km^2, with an area proportion to the whole country area of 0.02% and 0.06%. In terms of the city zone, according to the data from the Chinese Ministry of Construction, the city zone area was 3873km^2 in 1952, 5633km^2 in 1957, 7438km^2 in 1978, 9522km^2 in 1985, 17940km^2 in 1994 and 20214km^2 in 1996. In 1996, the city zone area accounted for 0.20% of the whole country area; another material from Chinese Bureau of Statistic shows that the construction land was 67,300 km^2 in 1949 and 328,000 km^2 in 1990, with a ratio to the whole country area of 0.70% and 3.42%. In 1990, the surveying result of Institute of Geographical Sciences and Natural Resources Research, CAS (Chinese Academy of Science) is: the whole country area of construction land was 324,000 km^2 and its ratio to the whole country area was 3.38%. According to the investigation of land use status quo in the whole country, the area of construction land was 295,400 km^2 and its ratio to the whole country area was 3.08%. And with the Bulletin of China's Land Resources of the Ministry of Land and Resources P.R.C, it's found out that the area of construction land was 306,800km^2 in 2001, 307,300km^2 in 2002, 310,200km^2 in 2003and 315,500km^2 in 2004, and the corresponding ratio to the whole country area was 3.10%, 3.20%, 3.24% and 3.29%.

1.6 Unutilized land changes

According to the national statistical materials, the unutilized land area was 3149,000 km^2 in 1949 and 2561,000 km^2 in 1990, and the corresponding area ratio to the whole country area was 32.8% and 26.68%. According to the measurements of Institute of Geographical Sciences and Natural Resources Research, CAS (Chinese Academy of Science), the unutilized land area was 2151,000 km^2 in 1990, which was about 22.40% of the whole country (Wu Chuanjun, 1994).

To sum up, we give the following table to demonstrate the land use change of China in the recent 55 years (Table 1). The general characteristics of the land use change of China in the recent 55 years can be concluded as follows:

The farmland reached the peak in the end of 1980s and then began reducing with fluctuation; the forestland is increasing slowly with an increasing ratio of 0.2% per year; the area of grassland in China changes little while the quality of grassland, especially the natural pasturing land changes a lot; the water area is increasing slowly with an increasing ratio of 0.03% per year, which is related to the increase of reservoirs and the wetland protect projects; the construction land is increasing very year with an increasing ratio of 0.05% per year. Seen from the absolute changing range aspects, in the recent 55 years, the farmland increased by 25%; the forestland increased by 88.2%; the grassland decreased by 1.48%; the water area (wetland) increased by 71.36%; the urban and rural dwelling, industrial and mining land increased by 3.47 times; the transportation land increased by 2.7 times; the unutilized land decreased by 26.2%. So the urban and rural dwelling, industrial and mining land has the biggest increasing range, and then follows transportation land, forestland, water area and farmland; the unutilized land has the biggest decreasing range, and then follows the grassland.

Table1 the land use change of China from 1949 to 2004

Type / Quantity / Year		Farmland	Garden plot	Forestland	Grassland	Water area	Construction land			Unutilized land（other lands）
							Urban and rural dwelling, industry and mining land	Transportation land	Subtotal	
1949	Area（10^4km^2）	97.90	1.07	125.0	391.2	22.50	4.73	2.00	6.73	315.6
	%	10.20	0.11	13.02	40.75	2.34	0.49	0.21	0.70	32.88
1985	Area（10^4km^2）	125.18	6.00	196.55	261.09	35.96	19.87	7.21	27.08	308.14
	%	13.04	0.63	20.47	27.20	3.75	2.07	0.76	2.81	32.08
1996	Area（10^4km^2）	130.04	10.02	227.61	266.07	38.40	24.08	5.47	29.55	258.31
	%	13.55	1.04	23.71	27.72	4.00	2.51	0.57	3.08	26.91
2004	Area（10^4km^2）	122.44	36.82	235.05	262.71	38.48	25.73	5.82	31.55	233.05
	%	12.75	3.84	24.48	27.37	4.01	2.68	0.61	3.29	24.26
Notes	1. In the data of 1949, the forestland contains both wooded forestland and non-wooded forestland; the grassland contains both artificial utilized grassland and natural utilizable grassland.									
	2. In the data of 1949, the garden plot contains all kinds of economic gardens; the urban and rural dwelling, industry and mining land contains water conservancy establishment land.									
	3. The forestland here contains non-wooded forestland with a crown density less than 0.3, so the data here is larger than the statistical data from the State Forestry Administration of China.									

2. Eco-environmental problems evolution of China

Recently, the major Eco-environmental Problems in China are land degradation, environmental pollution, biodiversity reduction and nature disasters. Land degradation includes soil-water losses, wind soil erosion, grassland degradation and secondary salinization. Environmental pollution includes air pollution (such as acid rain), water pollution (such as red tide), and solid waste pollution (including pollution by medical waste and nuclear radiation). The biodiversity reduction represents the decreasing or extinction of special species. The increase of nature disasters is mainly caused by the growing vulnerability of nature disasters (such as earthquake, typhoon, flood, and storm surge), and the expansion of high-risk areas.

2.1 Land degradation

According to the statistics from the Ministry of Water Resources, the total soil erosion area of China in 1973 was 1.177 million km^2, with a ratio to the whole country area of 12.3%, in 1990 1.974 million km^2 and 18.69%, in 1996 1.827 million km^2 and 19.00%, and in 2000 1.650 million km^2 and 17.19%. It could be drawn that, in the mid 1990s, soil erosion reached its peak, and it is just the counterpart of the peak of the farmland area. It could be seen that soil erosion is closely related to slope

(whose angle is more than 15 degree) cultivation. Just a year after this peak year, the Yellow River dried up for 227 days. Two years later, serious floods happened in the mid-lower reaches of Yangtze River basin, lower reaches of Huaihe River Basin and Nenjing River Basin. However, from the data of precipitation, it could be concluded that North China was just in a period of aridification. Thus, serious floods and droughts are not only induced by aridification, but also have close relationship with soil erosion. The drying up of Yellow River dues to both soil erosion and aridification, but the floods in Yangtze River Basin, Huaihe River Basin and Nenjiang River Basin could be directly attributed to soil erosion. Besides, from the perspective of the whole country, during the mid 1970s to mid 1990s, the growth of the farmland area was the root cause of national-wide soil erosion. From 1973 to 1996, the ratio of soil erosion area to the whole country area increased by 6.7%, and the area of soil erosion increased by 55.23% from 1973 to 1996, accompanied with a farmland-increasing rate of 27.98%.

Based on the investigation of Lanzhou Desert Research Institute, Chinese Academy of Science and Academy of Forest Investigation of China, it is concluded that though desertification in certain parts of China was controlled, the desertification land was still increasing in general. In the 1970s, the expansion rate of desertification land was 1560 km^2/a. In the 1980s, it was 2100km^2/a. In the beginning of 1990s, it was 2400 km^2/a; while in the end of 1990s, it was 3436 km^2/a. From the 1970s, especially since the 1980s, north China was in the period of aridification, and the irrational human activity (over grazing, reclamation and clear cutting) was the reason for the serious dust storm disaster in 2000. Till now, the area of desertification land of China is about 1 million km^2, with a ratio to the whole country area of 10.42%. According to the report from State Administration of Forestry, by the end of 2004, when forest cover ratio of China reached 18.20%, the trend of land desertification was somewhat controlled. Compared to the aridification trend of the northern China, it could be attributed to the project of “three-north” shelter belt system, desertification controlling projects. However, it should be taken more attention to the trend of aridification in northern China, and desertification control is still a very rough issue.

Grassland degradation has some relationship to soil erosion and desertification. It is calculated that, in the 1970s, degraded grassland took 15% of the total grassland area; in the 1980s, it reached 622,9 00 km^2, taking 30% of the total grassland area; in 1990s, it increased to 870,1000 km^2, taking 9.06% of the whole country land and 50% of the total grassland area; till the beginning of this century, the area of degraded grassland increased to 90% of the total grassland area. The increase in degraded grassland, is not only related to the drying trend but more to overgrazing. It has been proved that, grassland quality could be reserved by protecting, and overgrazing is the main reason for grass land degradation. In 1947, every sheep could occupy 4.1 hm^2 grassland, while in 1965 each sheep has only 0.97 hm^2.

Land salinization in China is closely related to aridification and is also with regard to enlarging agricultural irrigation area of northern China. In the 1970s, the total area of salinized land in China was 266,700 km^2, taking 2.78% of the whole country area. In the 1980s, it was 369,300 km^2, taking 3.85%. During the period of 1985-1996, salinized land in Xinjing Province took 29.2% of its total farmland area. Also, it took 16.7% in North China, 8.1% in Losses Plateau, 7.5% in Northeast China, 5.1% in South China, 3.7% in mid-lower reaches of Yangtze River Basin and 0.1% in Southeast China. Compared to the period of 1975-1979, it reduced by 2.4% in Xinjiang Province, 0.2% in Northeast China, whiled increased by 1.5 in Losses Plateau and South China, 0.8% in mid-lower reaches of Yangtze River Baisn, 0.6% in North China and 0.1% in Southeast China. Though land salinization can be attributed to different reasons in different regions of China, aridification is the main reason. Also, reclamations in wetlands can also induce land salinization. Besides, over exploitation of ground water

can also lead to salinization.

2.2 Environmental pollution

The environmental pollution in China has expanded from land to ocean, from the surface water to the ground water, from general emissions to deleterious pollutants. It has become to a complex status of co-existing of point source pollution and non-point source pollution, overlapping of life pollution and industry pollution, integrated primary pollution and secondary pollution. In some areas and river basins, such as Yangtze River Basin, Pearl River Basin, and Bohai Sea Circle, it has serious multi-polluted problems of air, water, as well as soil pollution, which threaten the security of ecosystem, food and health. Roughly speaking, the economic losses caused by environmental pollution accounts for 3-8% of China's GDP.

Emissions of water pollution have greatly exceeded the carrying capacity of water, the eutrophication making water quality worse. In 2003, only 38% of 409 monitoring transects in seven main rivers of China were over class III standard, which can be used as concentrating drinking water sources. There were 30% transects with water worse than class V, which is seriously polluted and almost useless. In most of the lakes in China, the concentration of nitrogen and phosphor has exceeded the national standard. In over 200 lakes in east and southwest of China, 80% of them are eutrophicated, and aquicolous ecosystems are seriously degraded. Nearly half of the water sources for urban drinking water are under national standard, and almost 360 million rural people still could not access to standard drinking water. Seawater exceeding class IV takes 26.5%, and could not be used for industry and seaports. Due to uncontrolled polluted industrial water, pollution accidents occurred frequently in recent years.

Air pollution in urban areas is still a big problem. In 2003, 41% of 340 cities under supervising in China has good air quality and the percentages of light polluted city and sever polluted city are 34% and 27% respectively. Most large cities are seriously air polluted and even have secondary pollution. The emissions of nitrogen oxides, ozone and particular matter has increased obviously, and visibility has declined in a great degree. It's difficult to see blue sky in many cities. In 2002, China is the largest source of SO_2 emission and emits 19.95 million tons of sulfur oxides. The area suffered by Acid Rain reach about 30% of China. Acid sediments, photochemical smoke and particular granules are main regional pollutants in metropolitan areas. According to the survey of Word Bank, China will pay 390 billion US dollars for the diseases caused by pollution from coal burning, which equals to 13% of the total GDP in 2020.

The pollution of solid waste to air, water and soil is getting worse these years. In 2002, the disposing of domestic garbage reaches 136 million tons. Urban garbage grows 7-10% each year, which is far more than the disposing rate. Stacking amount of solid waste is over 6 billion; and the harm of deleterious chemicals and hazard waste has appeared; electronic waste such as wiring waste, used battery and cars will grow twice. Every year, China produces about 950 million tons of industrial solid waste, which has 10 million tons of dangerous waste threatening the safety of ecosystem and human health. Besides, along with the development of nucleus electricity industry, the disposition of nucleus waste will be a tough environmental and security problem.

Those environmental problems mentioned above have close relationship with rapid industrialization and urbanization recent years. Since the 1990s, the emissions of various pollutants have increased slower than ever before, and the ratios of emissions to GDP have decreased greatly. These tendencies have become more obviously after 2000. Namely, more efforts are needed to achieve the technical progress of pollution-abatement and the "Zero" Low Emission.

2.3 Decline of biodiversity

According to the statistics, 20% of high-class plants are facing extinction. 190 of 1121 species listed in "Trade in Endangered Species of Wild Propagation" distribute in China. Besides, invasive species has become a serious problem to ecological security, and caused large losses as well. There are close connections among the decline of biodiversity, degradation of natural ecosystem, and human activities. The land use manner and intensity is the main artificial driving force of this process.

2.4 Natural disaster effect

The losses induced by natural disasters have been increasing gradually in recent years. The loss amount is growing from 100 billion in the 1980s and the early 1990s to 200 billion in the late 1990s. Although this tendency is similar to the growth of GDP, the ratio of disaster loss to GDP has declined with fluctuation. This decline tendency is more obvious in the 21 century. Recently, with the increasing

effect of nature disasters, besides high-risk areas, some river deltas in coastal distircts, with high-developed economic condition as well as vulnerability and resilience to disaster, also face huge disaster risk. Some unreasonable human activities, including reclamation, wetland occupying, land clearing on steady slopes, urbanization, and the increase in the proportion of industry land and transportation land, will dramatically increase the vulnerability to nature disasters such as earthquake, typhoon, flood, storm tide, dust storm, coast, debris flow, snow disaster and so on. The process of urbanization and increase of other construction area may increase runoff by increasing land runoff coefficients, consequently increased peak flux and shorten concentration time. Soil erosion have caused the ascend of riverbed and lakebed, leading to man made rising water level and higher flood risk, which could be described as “small hazard but huge disaster”. The water level ascend induced by human activities is about 2 meters in Dongting Lake Areas. The dikes of the lower reaches of Yellow River are now 15-20 meters higher than the nearby ground. If the dike failures happened, the result is unimaginable.

Above all, high-risk area is growing in China, and some vulnerable areas may face many serious problems.

3. Regional land use/cover pattern under the eco-environmental security

Regional land use pattern not only influences the above eco-environmental problems, but also makes its contribution in regional and global climate change through changing the earth-surface physical characteristics and the geo-biochemical process. So it’s significant to seek a new land use pattern that is eco-environment secure and does good to control global warming. This is not only beneficial to improve ecosystem health and environmental quality and advance sustainable development of China, but also helpful to maintain the ecosystem health in Asia and the whole world.

3.1 Adjust land use pattern to change and improve the ecosystem serving function

Based on remote sensing materials, we measured the Chinese ecological capital in the 1990s. And the measuring results prove the effect of the series of ecosystem recovery and reconstruction countermeasures implemented by Chinese government (Liu Jiang, 1994). The ecological construction projects, such as the construction of the project of “three-north” (North China, Northeast and Northwest) shelter belt system, the returning embankment to lake, the returning farmland to forestland or grassland, the returning pasturing land to grassland, the sandy dust source control of Beijing and Tianjin, the water and soil conservation project in the up-mid reaches Yangtze River and Yellow River, the coast defending forestation, the savage forest protecting project, the desertification prevention project, the wetland protecting project, the biodiversity governing and natural protecting district construction project, has done great contribution in controlling the eco-environmental problems. And in fact, all these eco-environment construction projects are national-wide land use pattern adjustment projects (Fu. et al., 1999). According to our experiments in Huangpuchuan valley of Yellow River (about 3700km^2) in Inner Mongolia of China (P. Shi et al., 2004), under the land use status quo pattern of 2000, the observed soil erosion quantity is 15974.4t/km^2.a, which is 5300t/km^2.a higher than the allowable natural erosion threshold of 10974.4t/km^2.a. After optimizing the present land use pattern, the soil erosion modulus reduces to 9868.0t/km^2.a, and it’s estimated that in 2013 the soil erosion modulus of this whole valley will reduce to 3730.14 t/km^2.a, which is significantly lower than the allowable natural erosion threshold. Compared with the 2000 land use pattern, the 2013 land use pattern will be greatly improved: the forestland will be increased from 6.8% to 14.0%, the shrubbery from 34.23% to 36.52%, the grassland from 27.08% to 36.02%, the urban construction area from0.09% to 0.15%; the farmland

will be reduced from 11.0% to 9.75%, the bare sandstone from 13.69% to 0.69%, the bare sand from 4.17% to 0.0%; the water area almost remain the same. Besides, the land use pattern adjustment in sandy land can also gain good effect on the sand erosion and desertification control. The Horqin sandy land case study analysis in Inner Mongolia by Prof. Wang Jing'ai, proved this conclusion well (refer to Wang Jing'ai's report in this conference).

3.2 Improve the natural resources utilizing efficiency and benefit, and build resource- economical society

The average amount of water and land resource per person in China is very limited, and especially the average amount of farmland and freshwater per person is seriously lacking, which is only about one quarter of the world average level. With the rapid Chinese economic development and urbanization in recent years, the supply shortage of energy and raw materials occur, and almost half of the petroleum has to be exported. Also the wood and paper pulp supply is seriously hard up, owing to the natural forest protecting projects. Considering these facts, in the early 1990s, the Chinese scientists suggested Chinese government to promote the natural resource utilizing efficiency and benefit and implement resource-economical socio-economic development mode. At present, Chinese government has considered resource-economical society construction into the national economic and social development plan, and will be carried out throughout the country. So it's very necessary to propose the circulation economy mode-"resource utilizing economically, resource recycling and resource utilizing circularly ". In order to realize this goal, it's needed to establish strict land expropriation policy and water resource exploitation and using policy, enhance the "public ownership" reform to manage the national natural resources more efficiently, and clarify the proportion of the expropriated land profit shared by former owner, estate agency and state. Only in this way, the resource-economical society system can be guaranteed radically. Besides, it's also important to develop scientific resource-economical technology, and realize the new "less snatch from the nature and more output to the society" socio-economic mode.

3.3 Harmonize natural and social capital, and seek sustainable development mode

Base on fieldwork investigation, remote sensing materials and statistic data, the spacial relationship between regional ecological capital and GDP in China is analyzed. The result shows that the ecological capital of the whole country is in a lacking state. And especially the situation of the wide eastern area is very severe, namely the natural capital and the social capital are seriously maladjusted. In 2000, the ecological capital of China is 12391.195 billion RMB, and the Chinese GDP of this year is 9720.93 billion RMB, so their value ratio Ps is 1.275 (Shi Peijun et al., 2005). By similarly calculation, we found the 1994 Chinese Ps value equaled to 1.867, and this result fits the research estimation of Costanza et al. in 1997 well, who estimated the 1994 world Ps value to be 1.833 (Costanza et al. 1997). But the amplitude of ecological capital is lower than that of GDP in the same period, especially in the eastern coastal provinces. There are only three provinces with a Ps value more than 1, Guangxi 2.934, Hainan 2.534, and Fujian 1.008. In the other eastern coastal provinces, the Ps values are all less than 1, Shanghai 0.001, Taiwan 0.051, Tianjin 0.090, Beijing 0.139, Jiangsu 0.200, Shandong 0.291, Zhejiang 0.416, Guangdong 0.475, Liaoning 0.580, Hebei 0.619. So to realize the saltant development, the coastal districts have to solve the serious problem of ecological capital insufficiency first. That's why we suggest the ecological capital compensative transferring among different regions in China. It's important to enhance eco-environment construction and form more ecological capital in the western region, which can help solve the maladjustment problem of social capital and natural capital in the eastern region. Namely the eastern region with sufficient social capital should buy the ecological

capital from the western region. And by doing this, the central government can realize the east-west harmonious sustainable development through market mechanism. The core of this mode is to treat natural capital and social capital equally, namely " ecological construction being industrialized and industrial development being ecologically considered" (Shi Peijun, 2003). In this way, the ecological construction is not only a commonweal task, but also a serving industry to maintain the health of earth and human race (Shi Peijun, 2004). To increase ecological capital is not only a key part of international carbon trade, but also a key economic way to improve the eco-environment quality; to promote the reasonable distribution of ecological capital is not only the important task of land use pattern adjustment, but also the outcome of land use/cover change. Although the amplitude of ecological capital is still less than that of GDP, the ecological construction projects of China has displayed remarkable effect, because the ecological capital has been increasing from 8462.133 RMB Yuan/hm^2 in 1992, to 11276.231 RMB Yuan/hm^2 in 1995, to 12907.495RMB Yuan/hm^2 in 2000 (Shi Peijun, 2005). This nice ecological construction situation is very important for the realization of sustainable development in China, and can provide solid support to alleviate the environmental problems.

4 conclusion and discussion

4.1 Conclusion

Through comparing and analysis of large amount of land use/cover data derived from different resources, it's concluded that:

The areas of main land use types in China were increasing from the beginning of 1950s to the middle of 1990s. The farmland reached its peak in the end of 1980s and then began reducing with fluctuation; while the area of forestland was hovering from the end of 1970s to the middle of 1990s, and had apparently increasing tend since the end of 1990s. Just due to the increase proportion of farmland and the stagnation of forestland from the end of 1970s to the middle of 1990s, and under the aridification period of northern China since 1980s, serious ecological disasters occurred in China (such as the pollution accident in Huaihe River in 1994, the Yellow River drying up for 227 days in 1997, the unusual big floods in Yangtze River and Nengjiang River in 1998, the 12 dust storm events in Beijing which affected Beijing, Korea, and Japan in 2000, the serious pollution accident in Huaihe River again in 2004 and so on). And it is closely related to the great changes of land use/cover, the urbanization acceleration, and the village enterprises development, which are all related to the central government policies, including "special economic zones" policy, and the transform of land resource exploiting policy such as "United belonging and household production", "Compensative expropriation" and so on.

Since the end of 1990s, Chinese central government has adopted a series of strategic measures and implemented many eco-environment construction projects to strength the improvement and protection of ecological environment, which have already gained some initial success. A series of regional extensive land use pattern adjustment, such as improving the forest cover ratio, returning farmland to forest、returning pasturing land to grassland, returning embankment to lake and so on., have already contributed to the controlling of soil and water losses, desertification and natural disasters. Some degraded ecosystems have been recovered; the ecological capital has increased; and the emission amount of contamination of per production value has evidently decreased.

It's important to adjust land use pattern, improve utilizing efficiency and benefit of natural resource, and harmonize the increasing proportion between natural capital and social capital, which could apparently meliorate and improve the serving function of eco-environment, accelerate the establishment of resource-economical society, and then help to establish the regional sustainable

development mode that meet the requirements of Chinese situation. This shows that it is possible and feasible to confirm the land use pattern under regional eco-environment security.

4.2 Discussion

Based on the deep understanding of the mechanism of land system dynamics, it's becoming the key focused research field of GLP to strengthen the application of land use/cover change research results, under the background of global change and in the establishing process of sustainable development mode with the purpose to improve earth health and human health. Therefore, through adjusting international trade and implementing the ecological capital compensative transferring in the global, regional and local scales, associated with advocated carbon trade, the global eco-environment can be greatly improved and its serving function can be promoted well (Shi Peijun et al., 2005). To introduce ecosystem improvement and construction into industrial field, and realize the mode of "ecological construction being industrialized and industrial development being ecologically considered", it's needed to construct special financial support at international, regional and national levels. And then eco-environment secure and friendly land use policy can be established and land use/cover pattern under eco-environment security can also be confirmed.

Learning from the thoughts of harmonization of nature and earth, and harmonization of human and land in the Chinese traditional culture, and searching for an efficient way to harmony development and eco-environmental security, it's suggested to consider GLP developed by IHDP and IGBP as one of key research field (Moran E.F., 2003). And this will promote the application of the land use/cover research results in the sustainable development activities.

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