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Study on Land Use Structure Changes and Countermeasures

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Abstract Land structure change not only relates to the coordinated development of regional social economic, but also determines the ecological environment security in certain region. Ili river valley was chose as the study area. The scientific and quantitative assessment of land use structure and spatial pattern is significant to the sustainable development of the Ili river valley area. Based on the detailed investigation date of land use from 2002 to 2008, and social and economic statistics of the Ili river valley in eight counties and one city in 2008, the study area's land use structure changes were discussed in three aspects from the land use structure, the degree of land use, to the land use efficiency. The changes of land use structure were analyzed by the use of qualitative and quantitative methods. Factors that influence land use structure changes were analyzed. In the end, suggestions were put forward to optimize the management.

Key words The land use structure; Countermeasures; Ili river valley area; China

Land is the root of survival and foundation of development. Right now, China is in the transitional period of economic development. The coordination between economic construction and the use of land resource is extremely important. The analysis of land use structure aims to make people better understand the relevance among people, nature, society, economy and the spatial distribution of land use, so as to discuss the regional difference and rationality of land use distribution^[1]. Various production methods influence the land use structure, which in return lead to the changes in natural and ecological environment. The scientific and reasonable use of land resource can realize the sustainable development of social economy. In recent years, because of the urbanization and industrialization, most lands have been occupied for construction, especially the arable land, which leads to low land use efficiency, drastic decrease of arable land, and unreasonable land use structure. Therefore, study on the optimized land resource structure is good for the understanding of the relationship between economic activity and structural changes in land use^[2], which has a great significance in the realization of regional economic development, optimization of industrial structure, and sustainable use of land resources. The National Working Conference on Xinjiang put forward the thought of urbanization, new industrialization and agricultural modernization. The Ili River Valley in Xinjiang is considered as the preserved land resource for China. With the economic development in the valley, the land resource in the valley is constantly changing. Right now, there are many studies on the land use structure, such as Geni coefficient^[3], optimal linear programming technique, RS – GIS method, grey correlation method, neural network method, information coefficient and balance method, etc. Qualitative and quantitative methods were applied to discuss the process of land use changes and influence of land use changes. Measures to optimize the land use structure in Ili river valley were

put forward, so as to provide support for the sustainable utilization and ecological environment protection in the river valley.

1 General situation in the study area and data source

Ili River is an important international river in north Xinjiang, from the west part of Tianshan in Xinjiang. It is 360 km long and goes through Kazakhstan to Balkhash Lake. The annual runoff is 38.1 billion m³. The potential hydropower resources are 7.052 5 million kW.h. Influenced by river, the central and lower reaches of Ili River Valley is flat and the soil is fertile, which develops into rice, cotton and oil foundation. The Ili River Valley locates in the northwest of Xinjiang, 80°09'37.96" – 84°53'16"E, and 42°12'37" – 44°50'31"N, including Yining County, Yining City, Nileke County, Xinyuan County, Gongliu County, Tekesi County, Zhao-su County, Chabuchaer County and Huocheng County. The climate in the River Valley is mild continental climate. The annual average temperature was 10.4 °C and the annual sunshine hours are 2 870 h. The annual precipitation is 417.6 mm. The superior natural condition in Ili River Valley is good for the agricultural and husbandry development.

The social economy in Ili River Valley develops fast. In the end of 2008, the gross national product in eight counties and one city in the Ili River Valley was 2.404 263 million yuan. The total population was 2.6 million. The average net income of farmers and herdsmen was 4 053 Yuan. Ili River Valley is the most important production foundation of rice, oil, husbandry, beet, flax and fruits.

The economic data came from the *Statistics Yearbook in the Autonomous State of Kazakh State in Xinjiang* from 2003 to 2009. The land data came from the *Statistics Yearbook of Land in Xinjiang* from 2002 to 2008. The third cycle of land use system was applied for the land use classification, for agricultural land, construction land and unused land. Ten subcategories were divided, such as arable land, garden, forest, farmland, land for construction, roads and waters, etc.

2 Study on the changes of land use structure

The structural changes of land use reflect the ratio of various land use types in total land area. Studies on the structural changes of land use render people better understanding of the spatial distribution of population, nature, society, economy and land use^[1]. The changes of land use in Ili River Valley over the past seven years were discussed from three aspects, dynamic changes of land use, degree of structural changes in land use and the benefit of land use^[4].

2.1 Structural changes of land use The structural changes of land use are the comprehensive reflection of ecological environment system in certain region under the influence of human being and nature^[5]. As shown in Table 1, the land use structure in eight counties and one city kept changing. The total area in Yili River Valley is 5.527 163 9 million hm². The agricultural land increased by 4 220.65 hm² from 2002 to 2008. The land for construction has increased by 2 623.78 hm² in the past seven years. The unused land has reduced by 6 844.4 hm². Through the cultivation of land in Ili River Valley, the balance of land structure hasn't been broken, which meets the demand of local economic development towards land. In terms of land use structure changes, the land for construction increased in each year, all above 0.4%

Table 1 Changes of land use in the Ili River Valley

Year	Farmland		Land for construction		Unused land	
	Total area//hm ²	Annual changes//%	Total area//hm ²	Annual changes//%	Total area//hm ²	Annual changes//%
2002	4 655 747.89	0.01	83 947.82	0.42	787 468.1	-0.13
2003	4 657 051.77	0.03	84 335.18	0.46	785 776.9	-0.21
2004	4 658 784.32	0.04	84 697.84	0.43	783 681.7	-0.27
2005	4 659 532.12	0.02	85 212.32	0.61	782 419.4	-0.16
2006	4 659 422.30	0.00	85 827.47	0.72	781 914.1	-0.06
2007	4 659 243.78	0.00	86 343.43	0.60	781 576.7	-0.04
2008	4 659 968.54	0.02	86 571.60	0.26	780 623.7	-0.12

Note: The data came from the *Yearbook of Land Statistics in Xinjiang* (2002–2008)^[8].

2.2 Changes in the benefit of land use The GNP per acre, agricultural output of farmland per acre and construction land was applied to analyze the outcome of land use. As shown in Table 2,

Table 2 The changes of land use efficiency in the river valley of Yili

Year	GNP Million yuan	GNP per acre Million yuan	Agricultural output per acre Million yuan	Bene Yuanhm ²
2002	844 813	1 528	733	59 965
2003	912 129	1 650	757	66 377
2004	1 120 807	2 028	846	85 789
2005	1 396 949	2 527	945	112 251
2006	1 620 863	2 933	1028	133 023
2007	1 962 069	3 550	1232	160 740
2008	2 404 263	4 350	1398	202 442

Note: The data came from the *Statistic Yearbook of Land in Xinjiang* (2002–2008) and the *Statistic Yearbook in Xinjiang* (2003–2009).

the national economy in the river valley in Yili rose rapidly. The GNP and the total value of average GNP increased at a rate of 109%. The agricultural output per acre increased from 733 Yuan/hm² to 1398 Yuan/hm². The annual average increase speed

during 2002 and 2007. In 2008, influenced by national and regional land use policy, the growth speed of construction land decreased. From 2002 to 2005, the unused land decreased at a rate of 0.2%. Since 2006, Ili River Valley has been considered as the reserved national land resource bank^[6]. Policies on the scientific and reasonable plan of land use have been formulated to realize the coordination between ecological protection and regional economic development. Farmers' income mainly comes from farming. The regional land use should orient towards high technological content, high economic additional value, and high ecological benefit^[7].

2.2 Changes of land use efficiency Average gross national product, agricultural output and construction land were chosen to study the land use benefit. As shown in Table 2, the national economy in Ili River Valley achieved rapid development. The annual average gross national product and GNP per acre increased at a speed of 109%. The agricultural output enhanced from 733 Yuan/hm² to 1398 Yuan/hm² and the annual increase speed reached 99%. The annual average increase speed reached 113%. All in all, the benefit of land use in Ili River Valley increased fast, but the farmland bought in less benefit than the land for construction. With the local economic development, such gap would be widened if economic development mode hasn't been changed.

reached 99%. All in all, the land use efficiency rose rapidly. With the regional economic development, such gap would enlarge if the economic development mode can not be changed.

3 Study on the factors influencing the land use structure

3.1 Main principle analysis method

The main principle analysis method is applied to study the changes of land use structure in the river valley of Yili. Main principle analysis is to change several indicators into many comprehensive factors based on limited information^[10–11]. The comprehensive indicator is called main principle and there aren't any relevance among each main principle. Suppose there are n samples and m indicators, the linear equation is as follow:

$$y_1 = \mu_{11}x_{11} + \mu_{12}x_{12} + \dots + \mu_{1m}x_{1m}$$

$$y_2 = \mu_{21}x_{21} + \mu_{22}x_{22} + \dots + \mu_{2m}x_{2m}$$

$$\dots\dots\dots$$

$$y_n = \mu_{n1}x_{n1} + \mu_{n2}x_{n2} + \dots + \mu_{nm}x_{nm}$$

$$\text{In which, } \mu_{i1}^2 + \mu_{i2}^2 + \mu_{i3}^2 + \dots + \mu_{im}^2 = 1 (i = 1, 2, 3, \dots, m).$$

The basic step of main principle analysis is to choose indicator system. Then, SPSS 17.0 software is applied to process the chosen indicators. The relevant matrix, characteristic value, contribution rate of main principle, accumulated contribution rate and main principle load table.

3.2 Indicators and values The change of land use is the result of many factors, society, population, economy and environment. With the development of industrialization and urbanization in China, the reasonable distribution of arable land, labor force and capital is an important measure to promote the change of economic mode^[4]. Eleven factors were chosen for the study^[1]: GNP, output of first industry, output of second industry, total population, investment in assets, net income in rural families, GNP per capita, urbanization level, farmland, land for construction and total

retail sales. The chosen indicators are representative (Table 3–4).

Table 3 Analysis of land use structure of River Valley in Yili

Project	No.	Indicator names	Unit
Economic indicators	X ₁	GDP	Ten thousand Yuan
	X ₂	Output of first industry	Ten thousand Yuan
	X ₃	Output of second industry	Ten thousand Yuan
	X ₄	Investment of assets	Ten thousand Yuan
Social indicators	X ₅	Total population	Ten thousand Yuan
	X ₆	Net income of rural family	Yuan
	X ₇	GNP per capita	Yuan
	X ₈	Urbanization level	%
	X ₉	Total retail sale	Ten thousand Yuan
Land development	X ₁₀	Farmland	Hectare
	X ₁₁	Land for construction	Hectare

Table 4 The value of each indicator of land use structure in the river valley of Ili

Year	GDP	Output of first industry	Output of second industry	Total population	Assets	Net income of rural family	GNP per country	Urbanization level//%	Farmland hm ²	Land for construction hm ²	Retail sales
2002	844 813	341 423	305 279	191	43 766	2 275	4 417	30	364.97	75.46	250 769
2003	912 129	352 338	243 306	238	312 330	2 303	3 830	32	31.09	122.54	270 828
2004	1 120 807	394 189	391 507	242	371 035	2 576	4 639	32	504.37	166.64	349 096
2005	1 396 949	440 433	388 123	245	566 887	2 923	5 693	43	1 364.46	296.18	393 508
2006	1 620 863	479 161	477 834	249	616 575	3 165	6 520	43	385.77	135.09	447 764
2007	1 962 069	574 181	603 352	255	463 357	3 584	7 682	43	229.24	296.81	522 221
2008	2 404 263	651 694	783 319	260	673 754	4 053	9 264	42	577.66	79.42	633 976

3 Results

SPSS17.0 software is applied to study the land use change in eight counties and one city in the river valley of Ili. Standardization re-

sult, matrix of relevant coefficient, eigenvalue, characteristic value, contribution rate of main principle and accumulated contribution rate were shown in following tables.

Table 5 Result of standardization

Year	zx ₁	zx ₂	zx ₃	zx ₄	zx ₅	zx ₆	zx ₇	zx ₈	zx ₉	zx ₁₀	zx ₁₁
2002	-1.08	-1.04	-0.81	-2.14	-1.81	-1.06	-0.81	-1.28	-0.30	-0.98	-1.16
2003	-0.97	-0.95	-1.15	-0.09	-0.57	-1.02	-1.11	-0.95	-1.09	-0.48	-1.01
2004	-0.60	-0.58	-0.35	0.09	-0.30	-0.61	-0.70	-0.95	0.02	-0.01	-0.44
2005	-0.12	-0.19	-0.37	0.22	0.61	-0.09	-0.16	0.84	2.05	1.38	-0.12
2006	0.27	0.15	0.12	0.39	0.84	0.27	0.26	0.84	-0.26	-0.35	0.28
2007	0.87	0.97	0.79	0.66	0.13	0.90	0.86	0.84	-0.62	1.38	0.82
2008	1.64	1.64	1.77	0.87	1.10	1.60	1.67	0.67	0.20	-0.94	1.63

Table 6 Matrix of relevant indicators

Project	GDP	Output of first industry	Output of second industry	Total population	Assets	Net income of rural family	GNP per country	Urbanization level//%	Farmland hm ²	Land for construction hm ²	Retail sales
GDP	1.00	1.00	0.98	0.74	0.80	1.00	0.99	0.81	0.14	0.16	1.00
Output of first industry	1.00	1.00	0.98	0.72	0.76	1.00	0.99	0.78	0.11	0.16	0.99
Output of second industry	0.98	0.98	1.00	0.64	0.69	0.98	0.98	0.69	0.09	0.04	0.98
Population	0.74	0.72	0.64	1.00	0.90	0.73	0.64	0.73	0.14	0.40	0.76
Assets	0.80	0.76	0.69	0.90	1.00	0.79	0.73	0.87	0.39	0.29	0.81
Net income	1.00	1.00	0.98	0.73	0.79	1.00	0.99	0.82	0.15	0.18	1.00
GNP	0.99	0.99	0.98	0.64	0.73	0.99	1.00	0.78	0.14	0.11	0.98
Urbanization	0.81	0.78	0.69	0.73	0.87	0.82	0.78	1.00	0.42	0.52	0.80
Farmland	0.14	0.11	0.09	0.14	0.39	0.15	0.14	0.42	1.00	0.45	0.16
Land for construction	0.16	0.16	0.04	0.40	0.29	0.18	0.11	0.52	0.45	1.00	0.16
Retail sales	1.00	0.99	0.98	0.76	0.81	1.00	0.98	0.80	0.16	0.16	1.00

4 Suggestions on the modification and adjustment of land use structure

The national economy is closely related to land use, as reflected in the change of land use structure^[12]. During the change of land use in the river valley in Ili, the outdated concept, excessive economic development, blind exploitation of land and neglect of ecological protection result in low land use efficiency, soil pollution and destruction of ecological environment. Measures to modify the land use structure were proposed.

Table 7 Eigenvalue and contribution rate of main principle

Main principle	Characteristic value	Contribution rate//%	Accumulated contribution rate//%
1	7.999	72.716	72.716
2	1.652	15.020	87.735
3	0.676	6.149	93.884
4	0.488	4.436	98.321
5	0.176	1.604	99.924
6	0.008	0.076	100.000
7	0	0	100.000
8	0	0	100.000
9	0	0	100.000
10	0	0	100.000
11	0	0	100.000

4.1 Implementation of various land plans During the economic transition, the general plan of land use in the river valley of Ili should be modified timely. The relation among economic development, construction occupation and land development should be protected. Plan is the basic measure for macro adjustment and regional government should coordinate the relation between various land use plans and social economic development.

4.2 Intensive use of land resource During the Twelve – Five Year Plan period, land in the river valley of Ili should be modified to construct reasonable land use system. Firstly, every inch of land should be used appropriately. Secondly, the land use structure in Ili river valley should be modified. During the progress, regional government should guide companies and herdsman to increase the scientific and technological content in land use, and to improve the land use efficiency.

4.3 Sustainable development of land resources The development of land in the river valley of Ili is one of the seven large project in China^[6]. In the economic transition, economic structure should be adjusted and the river valley in Ili is developed into a rice production basement and fodder basement based on ample water and soil resources. During the Twelfth – Five – Year Plan period, the river valley in Ili faces economic development, fast population growth and environmental protection. It is necessary to realize the sustainable development of land resource in the river valley^[13].

4.4 Ecological environmental protection in the river valley

During the "Twelfth – Five – Year" Plan period, the river val-

ley in Yili faces many problems as economic development, population growth and environmental protection to change economic development mode and to adjust economic structure. The influence of environment protection has great significance towards the decision-making of land use^[14]. It is necessary to realize the coordinated development of regional economy, population, resource and environment.

4.5 Strengthening of land supervision The economic development in river valley of Yili is mainly based on traditional farming and animal husbandry. Regional government should change its concept and guide farmers to learn new technology. National land departments should supervise the land protection and economic development so that the land use would be scientific and reasonable.

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