Research on Grade Renewing of Cultivated Land at County Level: A Case Study of Daxing District, Beijing

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Abstract To create a scientific way to renew the grades of cultivated land at county level, monitoring points were set up according to the monitoring control regions and grade types of cultivated land in Daxing District, Beijing, and soil samples were collected to carry out chemical analysis. Afterwards, the input and output data of cultivated land in each village were surveyed to renew the grades of cultivated land. The results indicate that the average natural grade of cultivated land was 8.4, which was equal to that of 2004; the average utilization grade was 8.1, which was slightly higher than that of 2004; the average economic grade was 9.9, which was lower than that of 2004. It is concluded that it is scientific to renew cultivated land grades through scientifically setting monitoring points according to the monitoring control regions and grade types of cultivated land.

Key words Land management, Grade renewing of cultivated land, Quality monitoring of cultivated land, Grade type, Daxing District

In October 2009, Ministry of Land and Resources of the People's Public of China issued the achievements in the grade classification of national agricultural land, and firstly established the unified national and comparable basic data of cultivated land grades in quality, laying foundations for the protection and management of cultivated land taking quantitative management, quality control as well as ecological management and protection as guiding ideology. However, affected by the rapid development of industrialization and urbanization, returning farmland to forest or grassland and other artificial and natural factors, cultivated land in China has changed constantly in both quantity and quality. According to *Land Management Law*, the achievements in the grade classification of agricultural land should be fully renewed every six years. Meanwhile, *Land and Resource Investigation and Evaluation in the "12th Five-Year Plan"* (issued by Ministry of Land and Resources No. [2011] 98) proposes that we will comprehensively investigate and monitor the quantity, quality and ecological conditions of land resources, evaluate and renew the quality grade of national agricultural land, and finish the quality monitoring and production accounting of agricultural land in 150 counties in the major grain producing areas during the "12th Five-Year Plan". Therefore, it is urgent to renew the classification achievements of agricultural land grades based on the latest investigation results of land use situation, so as to make them serve the protection and management of cultivated land better.

At present, a small number of scholars have studied the update of cultivated land classification. For instance, Sun Weijie designed the technical route to renew the classification of cultivated land at county level from the aspects of grading unit, properties of grading indicators, land use coefficient and land economic coefficient[1], but didn't explain the data sources of each grading indicator; taking a county in Fujian Province as an example, Zhou Xiaowei *et al*. adjusted previous grading indicators to renew the classification of cultivated land at county level by using the original grading method[2], but didn't renew land economic coefficient, so there was no comparability between previous and new results, and the new results could not reflect the latest economic situation of land use; taking land remediation project areas and newly-added farmland as major renewing objects, Wu Minghua *et al*. renewed the grades of cultivated land at county level, and put forward new methods to calculate land use coefficient and land economic coefficient of land remediation project areas[3], but the comparability between new and previous land use and economic grades need to be discussed further, because the calculation methods of land use coefficient and land economic coefficient were different from those in *Regulation of Farmland Grading*. In according with the deficiencies in previous studies of renewing farmland grades in China at present, we mainly discussed the method to renew the grades of cultivated land at county level in Daxing District, Beijing City through scientifically setting monitoring points.

1 Research thoughts and data sources

1.1 General situation of the area studied Daxing District (116°13′ -116°43′ E, 39°26′ -39°51′ N), Beijing, a national basic farmland demonstration county, as well as the first national farmland quality grade monitoring demonstration county, is located in the south of Beijing City, bordering Tongzhou dis-

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tricts in the east, Gu'an County and Langfang City, Hebei Province in the south, Yongding River facing Fangshan District in the west, and Fengtai and Chaoyang District in the north. The district has jurisdiction over three streets, four regional offices and ten towns, the only suburban county that has two new satellite towns in Beijing, and its location advantages are richly endowed by nature, so it is called "the Portal of South Beijing" and "Green Sea and Sweet Garden".

The whole Daxing District is a flat alluvial plain caused by Yongding River. There is aeolian sandy soil, brown earth, moisture soil, paddy soil and swamp soil, including eight subclasses, 21 genera and 74 species. The soil parent materials are alluvial deposits from Yongding River, becoming thinner from the west to the east. It has a warm temperate semi-humid monsoon climate, with four distinct seasons, and dry and wet season are obvious, which is very favorable for crop production. According to the survey data of land use change in 2010, the district has a total land area of 0.103 6 million hm^2, wherein farmland area reaches 41 600 hm^2, accounting for 40.18% of total land area. Dry land and irrigated land area are 1 100 and 40 500 hm^2 respectively. As the rapid development and continuous optimization of agricultural structure, the quantity and layout of farmland in Daxing District in the suburbs have changed fast. Therefore, the study of renewing farmland grades in Daxing District will set a good example for renewing farmland grades of other metropolitan areas.

1.2 Research thoughts The farmland map spots extracted from the renewing database of the second survey on the status quo of land use in 2010 was used as the renewing units of cultivated land grades in Daxing District. Firstly, by using the spatial analysis method of near value assignment based on ArcGIS, the previous grading results of farmland was shown on the map spot of farmland in 2010 to be used as the background values of farmland grade renewing, and the boundary map of land remediation project areas where the land remediation project was carried out in 2004 (the basic year of farmland grading in Daxing District) –2010 was overlaid with the base map. Afterwards, some representative monitoring points were set up in the farmland in land remediation project areas and its surrounding area to monitor some indicators, and the natural grade of farmland could be renewed according to the changes of these indicators. The use grade and economic grade were updated based on the data of farmland input and output obtained through complete and sampling survey(Fig.1).

1.3 Data sources To make the renewing results of farmland grades and previous grading results comparable, we also adopted previous grading parameters and indicators, such as light and temperature potential productivity index, production ratio coefficient, the highest yield of a specified crop and its cost index[4] (Table 1 and 2). In Daxing District, the specified crops are winter wheat and summer corn, and its standard farming system is double cropping system in a year. In addition, the grades adopted in the study are at national level.

Farmland grading data, land use data renewed through the second survey on land use in 2010 and land use plan data were collected from Beijing Bureau of Land and Resources, and the data about land remediation project areas were provided by Daxing Bureau of Land and Resources. Meanwhile, some new data of grading indicators were testing data of samples collected from monitoring points, while the input and output data of the specified crops were obtained through field surveys.

2 Renewing methods of county-level farmland grades

2.1 Linkage between farmland grading results and renewing results of the second survey on land use

2.1.1 Graphic registration. Taking the graphic format and coordinate projection system of the secondly renewed land use map in 2010 as the criterion (.shp format, Beijing local coordinates), we carried out the format and coordinate transformation and geometric correction of the grading result map to put the two maps in the same projected coordinated system.

2.1.2 Division of renewing units. In order to manage the quantity and quality of farmland uniformly, with the aid of ArcGIS9.3, the farmland map spots were extracted from the renewing database of the second survey on land use in 2010 to be used as the renewing units of cultivated land grades in Daxing District.

2.1.3 Property transfer. Using the function "near" of ArcGIS9.3, the property data of farmland grading units were transferred in the property database of grade renewing units to establish a basic database for renewing farmland grades. Firstly, the non-point data of farmland map spots in 2010 were transformed into point data; secondly, these point data were linked with nearby grading map spots, so that the linked point data had their properties; finally, by using the function "jion", we sorted out the property tables and attached them to the map spots of farmland in 2010 to generate the basic database of farmland grade update.

2.2 Layout of monitoring points Some representative monitoring points were set up in the farmland in land remediation project areas and outside of the project area, aiming at renewing the farmland grades of the whole district according to the changes of monitoring indicators. Among them, a complete investigation was carried out in land remediation project areas, while a sampling survey was conducted in the other farmland.

2.2.1 Division of the monitoring control region. According to the natural, social and economic conditions influencing farmland quality, a big district was divided into small regions, and each region had the same natural conditions, land use level and land income level. The score of natural quality, land use coefficient and land economic coefficient can reflect the natural conditions, land use level and land income level affecting farmland quality. Therefore, natural condition division was carried out using cluster analysis method according to the score of natural quality; land use level division was done on the basis of land use coefficient, and land income level division was conducted based on land economic coefficient. Hereafter, the three zones were overlaid by using the overlaying function of ArcGIS9.3, and six monitoring areas in Daxing District were

obtained after the adjustment according to dominant factors and village-level administrative boundaries (Fig. 2).

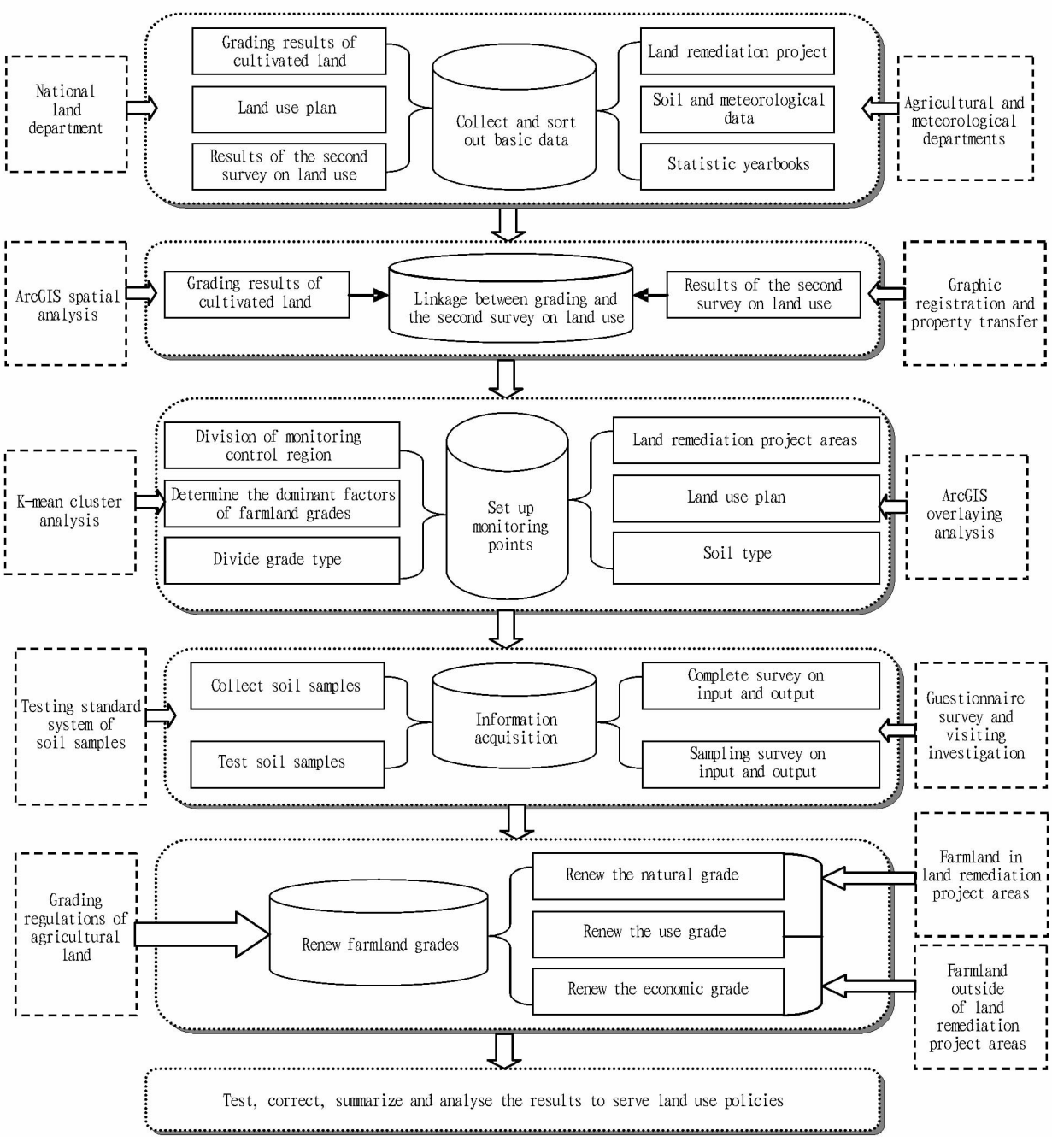


Fig. 1 Renewing thoughts of farmland grades

Table 1 Basic grading parameters of cultivated land in Daxing District

Specified crop	Light and temperature potential productivity index	Highest yield kg/hm^2	Production ratio coefficient	Maximum of yield-cost index //kg/yuan
Winter wheat	1 424	6 750	1.00	2
Summer corn	1 957	7 500	0.73	4

Table 2 Weights of grading indicators of farmland in Daxing District

Crop	Texture of surface soil	Profile form	Salinization	Content of soil organic matter	Drainage condition	Irrigation guaranteed rate
Wheat	0.20	0.15	0.12	0.13	0.15	0.25
Corn	0.22	0.16	0.13	0.14	0.15	0.20

2.2.2 Division of cultivated land grade type. A farmland grade type refers to a kind of farmland having a natural grade and a few of grading dominant factors[5]. The natural grade is the base of farmland grade system, so farmland grade type was divided according to natural grades and dominant factors. The natural grades of farmland were known, so determining dominant factors was the key to the division of farmland grade types. When adopting factor method to calculate farmland grades, we assumed that the farmland grade was the maximum if all grading indicators had a full score. As the decrease in the score of grading indicators, the farmland grade went down, so the indicators with a low score were used as the dominant factors of farmland grades. For various specified crops, each grading indicator had a certain weight, and the score of a certain character of an indicator might vary with the specified crop, so we respectively calculated the maximum and actual contribution value of an indicator in a grading unit to the natural grade index of farmland, and thereby their ratio was obtained, namely grade limit coefficient. Finally, the dominant factors of farmland grades were determined according to grade limit coefficient. Grade limit coefficient was calculated according to the follow – up formulas:

$$X_{ik} = r_{ik} / R_{ik} \quad (1)$$

$$r_{ik} = \frac{\sum_{j=1}^{j} w_{jk} \cdot f_{ijk} \cdot \alpha_j \cdot \beta_j}{100} \quad (2)$$

$$R_{ik} = \frac{\sum_{j=1}^{j} w_{jk} \cdot 100 \cdot \alpha_j \cdot \beta_j}{100} \quad (3)$$

where X_{ik} is the grade limit coefficient of grading factor k in grading unit i; R_{ik} is the maximum contribution value of grading indicator k in grading unit i to natural grade index; r_{ik} is the actual contribution value of grading indicator k in grading unit i to natural grade index; w_{jk} is the weight of grading factor k of specified crop j; f_{ijk} is the score of grading factor k of specified crop j in grading unit i; a_j is the light and temperature potential productivity index of specified crop j; β_j is the production ratio coefficient of specified crop j.

Generally speaking, the indicator with the smallest grade limit coefficient was often used as the dominant factor of farmland grades. However, the grading indicators with the grade limit coefficient of below 0.5 might be the major factors in future land remediation, and they had a great practical significance to the improvement of farmland grades, so these indicators were identified as dominant factors too. A grade type was composed of a certain natural grade and its dominant factors, and there were four grade types in Daxing District, including grade 8-topsoil texture, grade 8-organic matter, grade 9-topsoil texture + profile form, and grade 9-topsoil texture. Among them, grade 9-topsoil texture + profile form meant that topsoil texture was determined as a dominant factor because its grade limit coefficient was the minimum, while profile form was as a dominant factor because its grade limit coefficient was smaller than 0.5.

2.2.3 Layout of monitoring points. When arranging monitoring points, we should consider the monitoring control region, grade type, land remediation project areas, intensively contiguous newly-increased farmland, land use plan, soil type and other factors. First, the monitoring points representing a type of farmland grade were distributed in the contiguous farmland according to the area proportion of this type of farmland grade. Afterwards, we slightly adjusted the quantity and location of monitoring points according to the boundaries of land remediation project areas, soil type and land use plan, so that each grade type had a monitoring point in each monitoring control region at least, and there was a monitoring point in each land remediation project area at least; monitoring points distributed in all kinds of soil, and they were located in the basic farmland determined by the overall plan of land use and common cultivated land. In addition, there were more monitoring points in the intensively contiguous newly-increased farmland. There were 60 monitoring points in Daxing District (Table 3 and Fig. 2).

2.3 Collection and test of soil samples Each cultivated land having monitoring points had an area of 10 – 15 hm^2, so 5 – 20 surface soil samples at 0 – 20 cm were collected from each monitoring site. Beside collecting surface soil, we dug a soil profile in the newly-increased farmland to obtain soil profile form data. Through chemical experiments, we could obtain the data of grading indicators. Among them, soil texture, soil organic matter content and salt content were measured by using pipette method, potassium dichromate-sulfuric acid digestion method, mass method and indirect titration method based on EDTA respectively[6].

2.4 Survey on the input and output of cultivated land and agricultural infrastructure conditions The input and output of cultivated land and agricultural infrastructure conditions were investigated through questionnaire surveys and collecting statistical data. Various questionnaires were designed for villages, peasant household and monitoring points. Among them, every administrative village had a questionnaire, and a village head or cadre who knew the overall situation of the village was surveyed; each village had three questionnaires which were used to investigated three representative peasant households with high, medium and low crop yield respectively; there were several questionnaires for monitoring points, and the owners of cultivated land with monitoring points were surveyed.

2.5 Grade renewing of cultivated land

2.5.1 Renewing of natural grade. Based on the data of grading indicators obtained through chemical experiments and agricultural infrastructure data, the score of each indicator was determined according to the scoring rules of indicator grading in *Regulations of Farmland Grading* (TD/T 1004-2003), and then the score of each indicator in every map spot unit was renewed. Among the indicators, the score of topsoil texture, organic matter and degree of salinity in each control region was renewed according to their grade type. In the same control region, if there was only one monitoring point in the same grade type of cultivated land, the change in the score of its indicator at the monitoring point represented the increase in the score of the indicator in this grade type of cultivated land; if there were more than two monitoring points in the same grade type of cultivated land, the change in the average score of the indicator at

all monitoring points stood for the increase in the score of the indicator in this grade type of cultivated land; the sum of the background score and changing score of the indicator was the latest score of the indicator. If there is no human engineering, earthquake, flood and other great natural disasters, there is no change in soil profile form in several decades or a hundred years even, so the soil profile form of cultivated land where land use type did not change was not renewed. The scores of indicators for newly-added cultivated land were renewed according to the data of monitoring points and soil survey data. The scores of irrigation guaranteed rate and drainage conditions were updated based on agricultural infrastructure data. According to the scores of indicators renewed, the natural grade of cultivated land was determined in the light of *Regulations of Farmland Grading*.

Table 3 Distribution of monitoring points in each grade type of cultivated land in Daxing District

Monitoring Control area	Grade type	Area proportion//%	Number of monitoring points	Number of monitoring points proportion//%
I	Grade 8-topsoil texture	2.46	1	1.67
	Grade 8-organic matter	0.15	1	1.67
	Grade 9-topsoil texture + profile form	1.52	1	1.67
	Grade 9-topsoil texture	0.52	1	1.67
II	Grade 8-topsoil texture	8.68	5	8.33
	Grade 8-organic matter	0.31	1	1.67
	Grade 9-topsoil texture + profile form	4.81	3	5.00
	Grade 9-topsoil texture	4.40	1	1.67
III	Grade 8-topsoil texture	19.87	11	18.33
	Grade 8-organic matter	1.68	1	1.67
	Grade 9-topsoil texture + profile form	0.42	1	1.67
	Grade 9-topsoil texture	3.36	2	3.33
IV	Grade 8-topsoil texture	16.82	5	8.33
	Grade 8-organic matter	0.85	1	1.67
	Grade 9-topsoil texture + profile form	8.69	6	10.00
	Grade 9-topsoil texture	4.94	3	5.00
V	Grade 8-topsoil texture	3.23	2	3.33
	Grade 8-organic matter	1.12	1	1.67
	Grade 9-topsoil texture + profile form	7.70	6	10.00
	Grade 9-topsoil texture	4.44	4	6.67
VI	Grade 8-topsoil texture	0.64	1	1.67
	Grade 8-organic matter	3.39	2	3.33

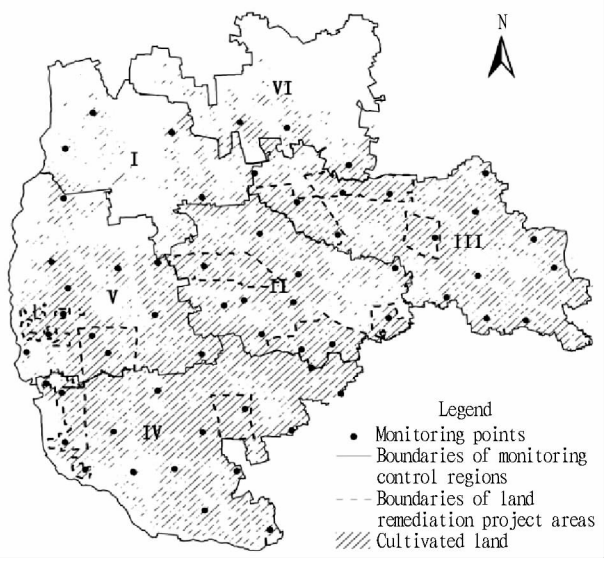


Fig. 2 Spatial distribution of monitoring points in each grade type of cultivated land in Daxing District

2.5.2 Renewing of land use and economic grade. Renewing land use coefficient and land economic coefficient were the key to renewing land use and economic grade, and land use coefficient and land economic coefficient could be determined according to *Regulations of Farmland Grading*. First, the region with the same coefficient was divided, and then a sampling survey on the input and output data of each region was carried out, finally the land use coefficient and land economic coefficient of each region were calculated. Every monitoring and control area had uniform natural conditions, land use level and land income level, so they could be regarded as the regions with the same land use coefficient and land economic coefficient. Therefore, the land use coefficient and land economic coefficient of each control area could be calculated according to *Regulations of Farmland Grading* as well input and output data, and then the land use coefficient and land economic coefficient of each map spot unit were updated. Hereafter, by using the renewed land use coefficient and land economic coefficient as well the natural grade index calculated based on the renewed scores of grading indicators, the use and economic grade of cultivated land was determined in accordance with *Regulations of Farmland Grading*.

3 Renewing results of cultivated land grades

The area of each farmland grade in Daxing District in 2010

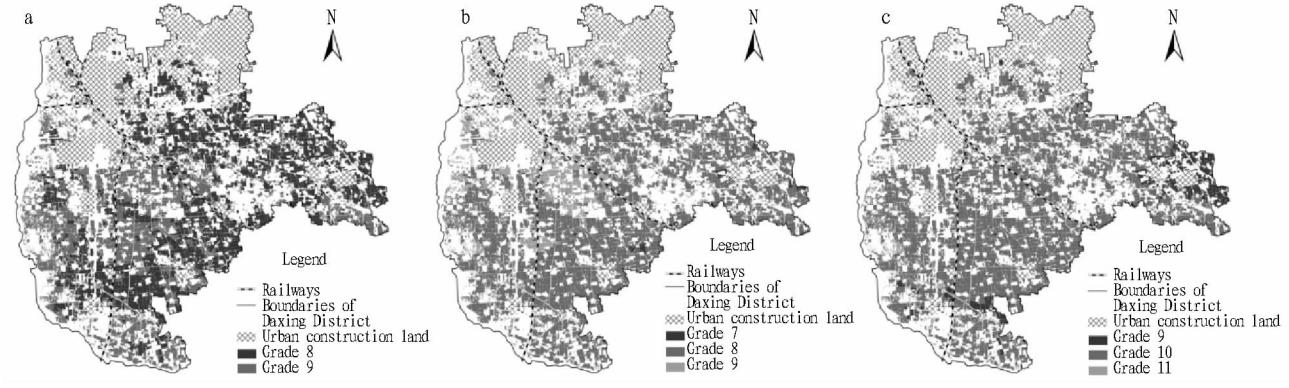
was shown in Table 4. Compared with the grading results of cultivated land in 2004, there was no change in the average natural grade of cultivated land, namely grade 8.4, and the area and its proportion of each grade didn't vary greatly, which is related to the stability of grading indicators; the average use grade of cultivated land in 2010 increased by 0.2, which is consistent with the slight increase in the average grain yield per unit area of farmland in recent years; the average economic grade of cultivated land in 2010 decreased by 1.1, and the great reduction resulted from the great raise of farmland cost caused by serious inflation and price increase during recent years.

Table 4 Grading results of cultivated land before and after renewing

Classification	Grade	Previous grading results of farmland in 2004			Renewing results of cultivated land grades in 2010		
		Area//hm^2	Proportion//%	Average grade	Area//hm^2	Proportion//%	Average grade
Natural grade	8	24 100.8	62.5	8.4	25 687.0	61.7	8.4
	9	14 474.7	37.5		15 940.9	38.3	
Use grade	7	–	–	8.3	356.4	0.01	8.1
	8	26 708.5	69.2		36 357.5	87.3	
	9	11 867.0	30.8		4 914.0	11.8	
Economic grade	8	8 845.8	22.9	8.8	–	–	9.9
	9	28 125.2	72.9		3 194.8	7.7	
	10	1 604.5	4.2		38 336.7	92.1	
	11	–	–		96.4	0.2	

Note: Taking the area proportion of each grade as its weight, each average grade was calculated by using weighted average method.

As shown in Fig.3, the natural grade of cultivated land was high in the northeast and low in the southwest on the whole, which was similar to the spatial distribution of previous natural grade and consistent with the rule that sandy soil in the southwest changes into clay soil in the northeast, showing that the renewing results of farmland grades were scientific. It is because that the whole Daxing District is a fluvial plain caused by Yongding River, and soil texture is the main factor influencing the natural quality of cultivated land. The use grade of farmland was 8 in most areas of Daxing District, and its area accounted for 87.3% of total area of cultivated land, while the grade was 9 along western Yongding River and in a small midland, revealing that Daxing District had a high land use level, and human utilization and management could make up the deficiencies of natural conditions of cultivated land to improve farmland quality. Additionally, the economic grade of 92.1% of cultivated land was up to 10, a small area of cultivated land with a grade of 9 mainly surrounded Caiyu Town in the east, but the previous farmland with a high economic grade chiefly distributed in the northeast near urban areas. It is because that due to the rapid development of urbanization, the cultivated farmland near urban areas would be occupied more easily, so that few farmers actively planted grain in the farmland, and thereby affecting farming benefit.



Note: a. Natural grade; b. Use grade; c. Economic grade.

Fig.3 Spatial distribution of renewed grades of cultivated land in Daxing District

4 Conclusions

Choosing the map spots of cultivated land obtained from the second survey on the status quo of land use in Daxing District as the renewing units of farmland grades, based on the previous grading results of cultivated land, representative monitoring points were set up mainly according to the the monitoring control region and the grade type of cultivated land, and land remediation project areas, land use plan, soil type and other factors should be considered. Afterwards, samples collected from monitoring points were tested in a laboratory to obtain the latest properties of some grading indicators, and the latest land use and income level were acquired through complete and sampling survey. According to *Regulations of Farmland Grading*, with the aid of ArcGIS, the method to renew the grade of cultivated land at county level is simple and easy, and the renewed grade results of cultivated land are real, which lays foundations for the annual variation of cultivated land in quantity and quality in future.

Among the renewed grade results of cultivated land, the

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struction. In industrial parks and concentrated areas, we should strengthen centralized layout and industrial agglomeration to change current dispersed layout, make industries move to industrial parks through financial transfer and employment system, and improve land use efficiency through planning and controlling use intensity of newly-added land to relieve land use contradiction. In rural residential areas, we ought to establish scientific programme for layout of towns and villages firstly, and then increase the investment in public facilities in rural centralized residential community, explore effective mechanism of benefit distribution of collective construction land transfer as well as the linkage of construction land, strengthen training and guidance of rural land co-operative organizations, promote the concentration of rural population toward towns and new rural communities, arrange and replace dispersed industrial land and rural residential land. Meanwhile, it provides spatial conditions for improving rural public facility level, promoting centralized control of industrial environmental protection, and enhancing government's public investment benefit.

4.5 Pay more attention to the inheritance and protection of cultural diversity In developing countries and regions, economic globalization easily results in homogenization of urban construction, while differentiation will make a region more competitive. Hence, during the process of planning formulation and implementation, we should pay more attention to the special protection and development of urban architecture, blocks, old towns and ecological culture with value of cultural heritage, which has a long-term important value for keeping the peculiar scene and cultural atmosphere and increasing living amenity and urban attraction, but current planning hardly pays attention to that.

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average economic grade of cultivated land went down greatly. It is because that all grading parameters and methods referred to *Regulations of Farmland Grading*, during the process of renewing farmland grades in Daxing District, and land economic coefficient was calculated based on actual "yield-cost index"/maximum "yield-cost index" model and the latest input and output data. Farming cost rised obviously due to the great price increase, while grain yield went up slightly, so that land economic coefficient and average economic grade of cultivated land declined. In fact, as the constant improvement of technical input and management level, the benefit of cultivated land should improve continuously, so we ought to further discuss whether the economic grade obtained by using the current grading method system of cultivated land is scientific, and the grading method of cultivated land can be improved through making the calculation model of land economic coefficient more scientific in the follow-up study.

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