GIS-based quality analysis on the cultivated land resources in poor areas of China

Ling LIU *[a,b,c], Ying Jie WANG [a], Jia Fu HAN [a]
[a]Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101,China;
[b]Graduate School of Chinese Academy of Sciences, Beijing 100039,China；
[c]Shandong Provincial Audit Office, Jinan 250012,China

ABSTRACT

Cultivated land resource is a key factor that affects the development standard of a region. By analysis of land use and land cover data in 2000, together with national geographical data, soil fertility comprehensive quality assessment data (1980), a GIS-based research is carried out on the quality analysis of cultivated land resources in poor areas. Firstly, data mining methods are used to gather the inter-relationships between the poor areas' cultivated land resources and its geographical background factors. Secondly, comparative analysis between the poor areas and non-poor areas is conducted to reveal the difference. Results show that the big difference exists in the basic natural features of the cultivated land resources between poor and non-poor areas. Although the quantity of cultivated land resource in those poor areas is not less than that of non-poor areas, the quality is lowly evaluated because of its high elevation, steep slope and earth surface roughness. Finally, after overlay analysis, the natural quality of cultivated land resources in poor areas is assessed according to their topographical and soil fertility features.

Keywords: cultivated land resources, quality, natural feature, poor area, GIS

1. INTRODUCTION

The poverty of China's rural areas is a problem that arose over long years in the past, and the distribution of the poverty-stricken population shows obvious geographical characteristics, i.e. most poverty-stricken people live in central and western China, in the barren rocky mountain area of southwest China, the arid Loess Plateau in northwest China and the impoverished Qinling and Daba mountain areas, and the frigid Qinghai-Tibet Plateau. The main factors behind poverty are adverse natural conditions, weak infrastructure and backward social development [1].

Poor areas that have been lagged behind in economic growth have many defective geographical conditions. In this paper, we will pay a closer observation on the cultivated lands' quality in poor areas, since cultivated land is an extremely important resource to produce materials for food and clothing, and also for economic growth.

According to existing cultivated land quality assessment researches, evaluation indicators system of cultivated land quality consists of three kinds of indicators, i.e. indicators of natural environment, indicators of soil, and indicators of social economy [2]. In this paper, researches are limited in the first two fields of above evaluation indicators system, mainly on the topographical feature and soil fertility of cultivated land, according to the data we can get.

2. DATA AND METHODOLOGY

2.1 Study site

There are three kinds of poor areas in China. The First one is 592 key counties for national poverty reduction and development which are issued by the State Council Leading Group Office of Poverty Alleviation and Reduction. The second one is the key counties for provincial poverty reduction and development issued by each province according to their own poverty situation. The third one is the 150,000 key villages for national poverty reduction and development.

* liuling_hb71@163.com; phone (86-10)64889047; fax (86-10)64889630. The research in this paper is sponsored by National Key Technology R&D Program "Research on monitoring technology of population movements in urban and rural areas", 2006BAJ11B02.

In the following researches, we focus on the first kind of poor area, that is, the 592 key counties for national poverty reduction and development. They are referred to as key counties for short. These key counties are mainly located in western and central part of China, and, are distributed in 21 provincial regions. In this paper, these 21 provincial regions are referred to as provinces with key counties. Except for these provinces with key counties, Hong Kong, Macau, and Taiwan, the other nine provincial regions have no key counties for national poverty reduction and development, and they are referred to as provinces without key counties.

In order to get a clearer understanding of the quality characteristic of poor area's cultivated land, we do comparative analysis constantly, between poor areas and entire country, between poor areas and non-poor areas. Even in the key counties alone, the natural conditions differ greatly, because China has a large boundary and the key counties scatters in a large range of area. According to official data, there are four major zones in China, i.e. the eastern region, the central region, the western region and the north-eastern region. We also compare the poor areas in different zone separately.

Related spatial information of above study sites are shown in Fig. 1.

Fig. 1. Poor Areas in China

2.2 Data Description

The basic geographical data is compiled in accordance with the 2007 Handbook of Administrative Divisions and the national map at a spatial scale of 1: 12,000,000 promulgated by State Bureau of Surveying and Mapping in 2006. The data of 592 key counties are prepared by researchers from Department of Cartography, IGSNRR (Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences). The 2000 land-use data at a spatial scale of 1: 1,000,000 are from RESDC (Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences). Data of national DEM with 1 kilometers' ground resolution, data of soil fertility's comprehensive quality assessment (1980) at a spatial scale of 1: 4,000,000 are both taken from the Data Sharing Infrastructure of Earth System Science.

2.3 methodology

Since above data have different spatial projections, projection transformation is firstly carried out to get a common coordinate system. Secondly, map splicing is carried out with ArcGIS software, because the land-use data are in a framed style. Then, slope data are calculated from DEM, clip and identity operations are done to prepare different study sites' land-use and soil fertility data. And then, further statistic analysis and comparative analysis are taken to find each study sites' distinct characteristics and the basic difference between them. It should be noted that comparative analysis are constantly made between key counties and entire country, poor areas and non-poor areas, key counties in different major zones.

After above operations, basic features of poor areas' cultivated land are revealed. Following overlay analysis is carried out to build up a simple evaluation criterion on cultivated land's quality in poor areas. Using the evaluation criteria that is based on cultivated land's topographical feature and soil fertility, we get a general concept of how many cultivated lands in poor areas are good, ordinary or bad, and where each kind of cultivated lands is located.

3. RESULTS

3.1 Topographical characteristic of poor areas' cultivated land

From the national DEM of 1 kilometers' ground resolution, we calculate the slope data of the country. By zonal statistic operation, we get the slope range of each key county. As shown in the following figure (Fig.2), 296 key counties' average slope are above 6° ,occupying a percentage of 50% in all key counties. In these counties, 131 counties' average slope exceed to 10° or above, which means about 22% of key counties lie in fairly rugged areas, and the cultivated lands there is hard to be cultivated.

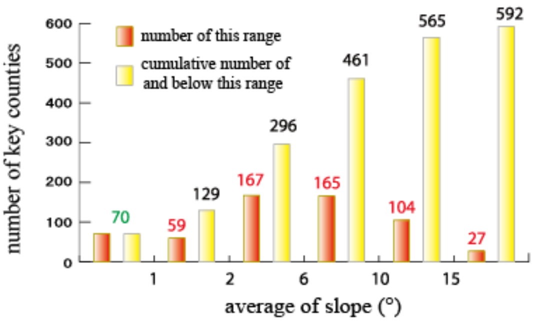

Fig. 2. key counties' slope range

From the land-use data of 2000, we get a series of derived data, including land-use data of each key county and each province, from which further comparative analysis is carried out. According to the land-use data, cultivated land is classified into four kinds according to their topographical features, i.e. plain-type, knap-type, hill-type, and steep-slope-type (with slope range of above 25°). Statistics of each type of cultivated land in five different study sites, together with the comparison between poor areas and non-poor areas, are listed in the following table (tab.1)

			provinces with key counties (A)	eastern region (B)	central region (C)	western region (D)	north-eastern region(E)
ratio of plain-type arable land (%)	1	poor areas	50.08	65.39	66.54	33.78	94.95
	2	non-poor areas	71.89	83.12	77.59	49.92	91.79
	3	whole study site	65.53	77.61	74.98	43.37	92.21
ratio of knap-type arable land (%)	4	poor areas	23.50	11.61	18.91	30.26	3.81
	5	non-poor areas	19.99	2.61	17.50	36.00	6.03
	6	whole study site	21.02	5.41	17.83	33.67	5.74
ratio of hill-type arable land (%)	7	poor areas	26.25	23.00	14.53	35.67	1.24
	8	non-poor areas	8.11	14.28	4.91	14.05	2.18
	9	whole study site	13.39	16.99	7.18	22.82	2.05
ratio of steep-slope-type arable land (%)	10	poor areas	0.17	1.59E-03	0.02	0.29	0.00
	11	non-poor areas	0.01	8.57E-10	1.46E-03	0.03	0.00
	12	whole study site	0.06	4.95E-04	0.01	0.13	0.00

Tab. 1. Area-composition of cultivated land (classified by topographical features). There are five study sites, i.e. provinces with key counties (Column A) and provinces with key counties in four major zones of China (Column B to E, whose headers omit 'provinces with key counties in' to keep an appropriate length). In each study site, comparative analysis is carried out among the poor areas, non-poor areas and the whole study site.

Tab.1 shows that in the first four kind of study site (Column A to D), the ratio of plain-type cultivated land in poor areas (Row 1) are noticeably lower than that in non-poor areas (Row 2) and the whole study site (Row 3), while the ratio of the other three kind of cultivated are higher than that in non-poor areas and whole study site, especially the ratio of the last two types are noticeably high. Above statistic result shows that in most poor areas there are fewer easily-cultivated cultivated lands than non-poor areas because of their high elevation, steep and rugged surface. Their cultivated land's quality defined by topographical features is relatively lower.

The following figures (Fig.3 and Fig.4) show the spatial characteristic of poor area's topographical features. Two types of cultivated land (hill-type and knap-type) constitute the main part of poor area's rugged cultivated land, and, they are concentrated in the east and south part of China's second Terrain-Zone, close to the line where the second and the third Terrain-Zones meet. As the figures show, key counties with higher proportion of hill-type cultivated land are mostly located in the provinces of Yunnan, Guizhou, Sichuan, Chongqing and Gansu, while key counties with higher proportion of knap-type cultivated land are mostly located around the middle part of the eastern boundary of western region.

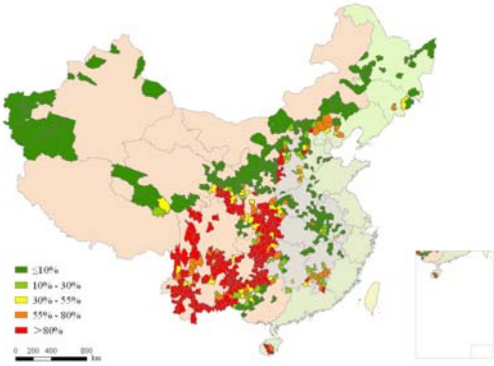

Fig. 3. Proportion of hill-type cultivated land in key counties

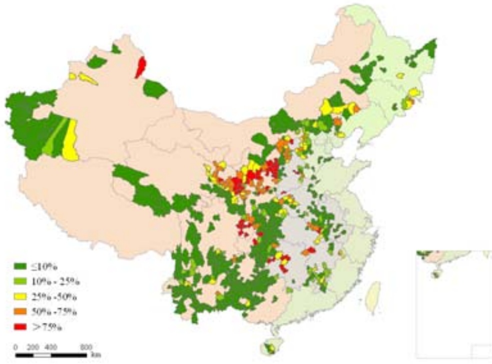

Fig. 4. Proportion of knap-type cultivated land in key counties

Following figure (Fig.5) shows the distribution of plain-type cultivated land in poor areas. Polygons in green color indicate key counties that have higher proportion of plain-type cultivated land. The figure shows that there are less key counties that have higher proportion of plain-type cultivated land in China, and they are concentrated in eastern and north-eastern region of China, some are located in western part of Xinjiang.

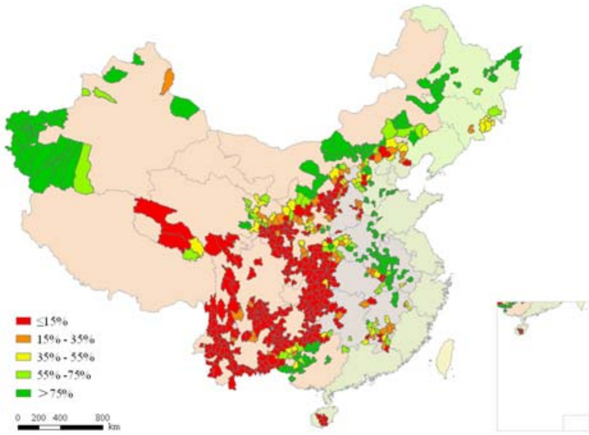

Fig. 5. Proportion of plain-type cultivated land in key counties

3.2 Soil-fertility feature of poor areas' cultivated land

In the data of soil fertility's comprehensive quality assessment (1980), soil-surface is classified into five fertility grades, i.e. rich, less rich, ordinary, less poor and poor. There are also some areas that have blank data, but the portion is small enough to be acceptable. By clip, identity and other operations in ArcGIS, statistic data of different study sites' soil's and cultivated land's fertility grade are gotten, and further comparative analysis are carried out.

Firstly, we do soil-fertility comparison among the entire country, provinces with key counties and 592 key counties.

		entire country	provinces with key counties	592 key counties
1	rich	2.40	2.85	1.48
2	less-rich	17.96	17.48	14.68
3	ordinary	53.66	53.49	60.58
4	less-poor	23.42	24.14	21.99
5	poor	0.46	0.35	0.04
6	blank data	2.10	1.69	1.22
7	less-rich and above	20.36	20.33	16.16
8	ordinary and above	74.02	73.81	76.75
9	less-poor and below	23.88	24.49	22.03

Tab. 2. Area-composition of soil with different fertility grades among three study sites (%).

As Tab.2 shows, compared with the entire country (Column A) and the provinces with key counties (Column B), the 592 key counties (Column C) has the lowest proportion of rich and less-rich soil (Row 1 and 2), and it's sum of these two proportion (Row 7) is also the lowest. However, its soil proportion of ordinary and above grade (Row 8) is about 2.5% higher than that of the other two study site.

		A	B	C	D	E	F	G
1	rich	1.90	2.29	1.22	0.00	0.00	0.01	12.64
2	less rich	12.81	14.66	12.65	4.33	4.93	9.65	57.16
3	ordinary	66.81	67.08	71.12	81.41	80.39	73.12	27.07
4	less poor	17.11	15.01	14.62	14.15	13.68	17.17	1.99
5	poor	0.82	0.49	0.02	0.08	0.00	0.03	0.00
6	blank data	0.54	0.47	0.37	0.03	1.00	0.03	1.14
7	less rich and above	14.71	16.95	13.87	4.33	4.93	9.65	69.80
8	ordinary and above	81.53	84.03	84.99	85.73	85.32	82.77	96.87
9	less poor and below	17.93	15.50	14.64	14.24	13.68	17.20	1.99

Tab. 3. Area-composition of cultivated land with different soil-fertility grades among seven study sites (%).Headers are coded to keep an appropriate length. The first three are entire country (Column A), provinces with key counties (Column B), and 592 key counties (Column C). The last four study sites are key counties in four major zones of China, that is, Eastern region(Column D), Central region(Column E), Western region(Column F), and North-eastern region(Column G).

Secondly, we do cultivated land's soil-fertility comparison among seven study sites. As Tab.3 shows, 592 key counties' proportions of rich soil cultivated land (Row 1), less-rich soil cultivated land (Row 2), and the sum of this two (Row 7), are overall the lowest in the first three study sites (Column A to C). But in Column D to G, the above three proportion varies greatly. In the first three major-zones' key counties (Column D to F), this three proportions are quite lower than that in Column A to C, while this three proportion in Column G are noticeably higher than that in Column A to C. From above findings, a conclusion can be drawn. That is, cultivated lands' soil-fertility in poor areas varies greatly among four major zones, and, north-eastern region's has the richest soil-fertility.

Following figures (Fig.6 and Fig.7) show the spatial information of poor area's proportion of cultivated land with rich and less-rich fertility soil, and, with poor and less-poor fertility soil separately. In Fig.6 many key counties' cultivated lands have a less than 25% proportion of rich and less-rich soil, and number of this kind of key counties is fairly big. Only a small number of key counties' cultivated lands have a higher proportion of rich and less-rich soil, and they are concentrated in north-eastern region and west part of Sichuan. In Fig.7, there are more key counties with a markedly-high proportion (higher than 45%) of cultivated land with poor and less-poor fertility soil. They are mainly located in the south and eastern part of western region, around the boundary between the second and the third Terrain-Zone of China.

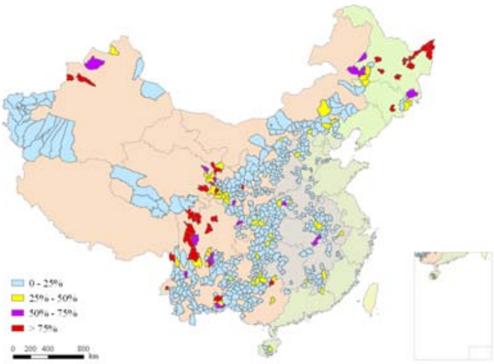

Fig. 6. Proportion of cultivated land with rich and less-rich soil in key counties

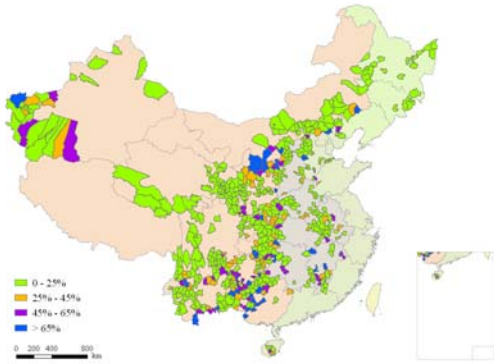

Fig. 7. Proportion of cultivated land with poor and less-poor soil in key counties

Following figure (Fig. 8) shows the spatial information of poor area's proportion of cultivated land with ordinary fertility soil. It shows that most of key counties' proportion of cultivated land with ordinary fertility soil are above 50%, and, more than one thirds of 592 key counties have a proportion of above 75%. That reflects a situation that there is less fairly-rich fertility soil in poor area's cultivated land.

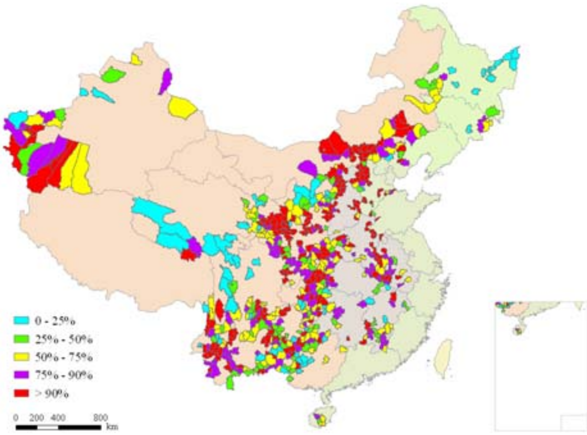

Fig. 8. Proportion of cultivated land with ordinary soil in key counties

3.3 Overlay results of cultivated land's soil fertility and slope in the poor areas

As mentioned above, this study is mentioned to build a simple evaluation criterion on cultivated land's quality. The criterion involves two indicators, one is topographical feature, while the other is soil fertility. Cultivated land's topographical feature is derived from the land-use code, that is, hill-type, knap-type, plain-type and steep-slope-type. Cultivated land's soil fertility is from the data of soil fertility's comprehensive quality assessment (1980). Referring the related researches [3], we define the overlaying formula as following, and the quality indicators' weight and their value ranges are listed in the following table (Tab. 4).

$$Q = \sum_{i=1}^{2} W_i F_i \tag{1}$$

	weight	type	value
topographical feature	0.5	plain-type	4
		knap-type	3
		hill-type	2
		steep-slope-type	1
soil fertility	0.5	rich	5
		less-rich	4
		ordinary	3
		less-poor	2
		poor	1

Tab. 4. Weights and value range of cultivated land quality evaluation factors.

Firstly, overlaying operation is carried out in each polygon and Q-value is gotten for each polygon. Then, the Q-value is calculated for each county, using a weighting method of each relating polygon's area. The formula for each county's Q-value is as following:

$$Q_i = \sum_{j=1}^{Ni} S_j Q_j \ / \ A_i \qquad (2)$$

In the above formula (2), Q_i indicates the Q-value of a county in 592 key counties, A_i indicates the area of this county, N_i indicates the number of polygon that composes this county, S_j indicates the area of each polygon, and Q_j indicates the Q-value calculated with formula (1) for each polygon.

When we get Q-value of each key county, the quality evaluation map of their cultivated land can be made, which is shown as Fig. 9.

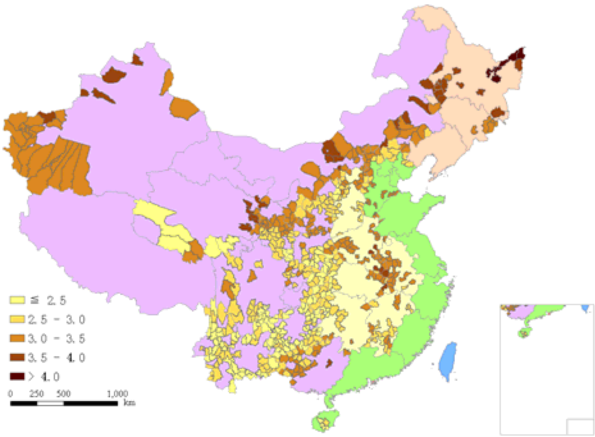

Fig. 9. Quality assessment on cultivated land in key counties

4. CONCLUSIONS

As shown above, GIS-based analysis is carried out on cultivated land's quality assessment in poor areas. With a simple quality evaluation criterion, we get a general impression of China's poor area's cultivated land's quality. That is, the highest quality (above 4.0) cultivated land is located at the north of Heilongjiang province, and the county number is very small. Some key counties in Heilongjiang, Inner Mongolia, Xinjiang, Qinghai have the second high quality (between 3.5 and 4.0) cultivated land, because of their fairly good topographical feature and soil fertility. Most of key counties in north-west China and central China have the ordinary-evaluated (between 3.0 and 3.5) cultivated land, and number of this kind of key county is fairly big. Key counties in south-west of China, which lie in the south part of Gansu, most part of Sichuan, Chongqing, Guizhou, Yunnan, and Hunan, Hubei, have the two lowest quality-evaluated (between 2.5 and 3.0, and below 2.5) cultivated land.

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