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Research on the spatial distribution characteristics of arable land natural quality grade in Yunnan province

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ABSTRACT

Understanding the distribution characteristics of arable land in Yunnan Province is significant to make the scientific decision for using and improving the natural quality of arable land. In this study, the distribution characteristics of the arable land grade including 129 counties were analyzed based on the accomplishment of cultivated land classification in Yunnan Province. The results showed that the average natural grade was 9.8 and ranged from 1 to 28, which meant that the natural quality of arable land was relatively lower in Yunnan Province. In excellent zone, the grade ranged from 2 to 21, plus 25 and 26, and the average grade was 9.3. In good zone, it ranged from 3-23, plus 1, and the average grade was 10.3. In medium zone, it ranged from 2-25, and the average value was 10.4. In poor zone, it ranged from 2-27 without 17, 18, 19 and 20, and the average was 8.1. The middle and poor arable land had the largest area, and concentrated in the middle and poor zone, which had influenced the average grade the most in the whole province. This research provides a reference for policy making about space arrangement optimization, quality improvement and ecology environment protection for arable land in Yunnan Province.

KEYWORDS

Arable land; Natural quality grade; Distribution; Yunnan province.



INTRODUCTION

Arable land is one of the important carriers for the development of human society, and human cannot even survive without it^[1]. Natural quality of arable land can fully reflect the influence of natural factors, which is related to social stability and sustainable development. In order to improve the management level of arable land resources and provide a scientific basis for land plan and use, Yunnan Province had evaluated all the arable land in its region since 2004, and completed cultivated land classification^[2-4]. Cultivated land classification adopted a unified technical specifications based on counties, and its outcomes can fully reflect the natural conditions of arable land and provide accurate information on the quality of arable land^[5-8].

Yunnan Province is the region with acute contraction between human and land area, but also a typical ecological and less developed region in China. With the development of the new urbanization, arable land resources will face greater pressure in the future in this province. Understanding the distribution characteristics of arable land can provide evidence to determine the scientific countermeasures of promotion and protection of it based on the spatial pattern. Current research on distribution of arable land quality usually based on land use or economic level, capacity and other aspects, while less combined natural quality with eco-environment^[9-14]. This paper had analyzed the distribution characteristics of arable land combined with eco-environment evaluation results based on cultivated land classification achievements, in order to provide the basis for quality promotion and protection policy of different arable land.

STUDY AREA AND DATA SOURCES

Study area

Yunnan Province is located in the southwest of China, and forms complex and diverse natural and geographical conditions because of southeast and southwest monsoons, and Tibetan Plateau. It contains 16 states within a total of 129 counties in its administrative region, whose area is 394,000 square kilometers. Among them, arable land accounts for 15.97%, garden accounts for 2.12%, woodland accounts for 57.69% and grassland accounts for 2.05%.

Yunnan Province is a predominantly mountain plateau mountainous province, whose landform is complex with mountains, hills and plain. Among them, mountains account for 84%, hills account for 10% and plain account for only 6%. The arable land is mainly distributed in the mountain and hill area, and slope arable land accounts for 64% of the total arable land with the properties of scatter, serious erosion and low productivity^[15].

Data sources

This study was based on the cultivated land classification achievement of Yunnan Province and eco-environment evaluation results by remote sensing investigation. According to the province's grading results, the natural quality gets better along with the increase of grade^[16-18].

DATA PROCESSING AND ANALYSIS METHODS

Data processing

It adopted area weighted average method when the mean natural quality of the whole region was needed.

$$Y = \frac{\sum_{i=i_{\min}}^{i_{\max}} i \times S_i}{S_{\text{total}}} \quad (1)$$

Y = the mean natural quality

i = natural quality grade

i_{\max} = the maximum of grade

i_{\min} = the minimum of grade

S_i = area of arable land belongs to i grade, hm^2

S_{total} = total area of arable land, hm^2

Analysis methods

It adopted spatial analysis tool of ArcGIS based on the accomplishment of cultivated land classification, and analyzed the distribution characteristics of natural quality on the scale of eco-environment evaluation district with the methods of spatial overlay, correlation analysis and so on.

RESULTS AND ANALYSIS

Quantitative distribution characteristics of arable land natural quality grade

According to the accomplishment of arable land classification, there are 13,868 provincial-level evaluation units with a total area of 6119,500 hm^2 . The grade of natural quality ranged from 1 to 28, among which grade 1 was the worst while grade 28 was the best, and the area weighted average grade was 9.8. From Figure 1, it showed that the natural quality grade is generally low with a typical skew normal distribution. Arable land of grade 8 and grade 9 had the greatest area, accounted for 13.72% and 13.71% respectively, while grade 1 and grade 28 had the smallest area whose proportion was close

to zero. Arable land ranged from grade 4 to grade 18 is the main part with an area of 5963,106 hm², which accounted for 97.44%. Area of arable land ranged from 1 to 3 was 2,2020 hm², which accounted for 0.36%. Area of arable land ranged from 19 to 28 was 13,4424 hm², which accounted for 2.20%.

It is divided into four grades named low, intermediate, advanced and superior depending on the scopes of natural quality grade of 1-7 grades, 8-14 grades, 15-21 grades and 22-28 grades. According to the division results, area of low grade arable land was 1619,249 hm², which accounted for 24.46%. Area of intermediate grade arable land was 3783,854 hm², which accounted for 61.83%. Area of advanced grade arable land was 666,759 hm², which accounted for 10.90%. Area of superior grade arable land was 49,687 hm², which accounted for 0.81%.

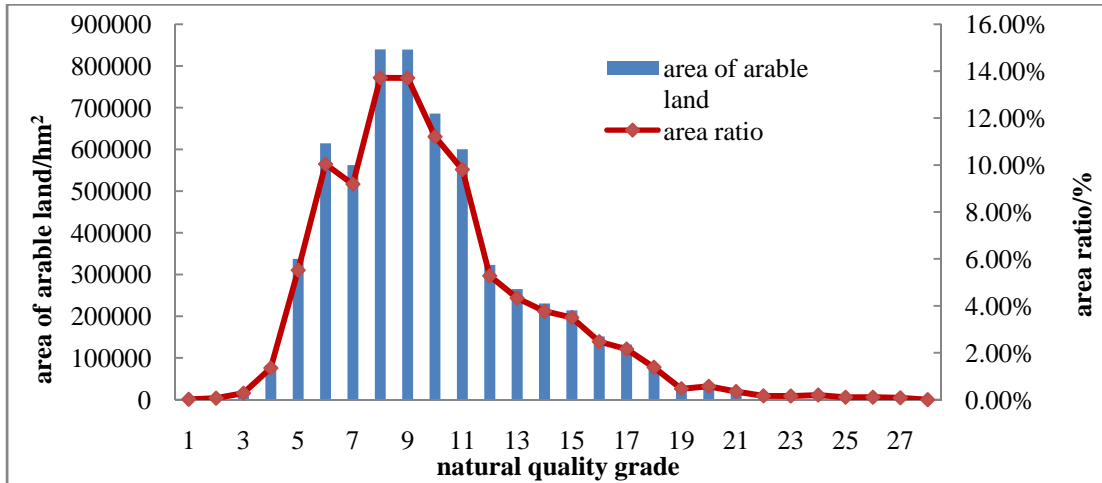


Figure 1 : Structure of arable land natural quality grade in Yunnan province

Distribution characteristics of arable land natural quality grade combined with eco-environment district

The eco-environment of Yunnan Province had been divided into 5 zones named excellent zone, good zone, medium zone, poor zone and worse zone by 6 indexes of forest coverage rate, water resource, slope arable land ratio, unused land ratio, soil erosion ratio and population density^[19,20]. It showed in Figure 2 that the excellent zone was mainly distributed in the center, northwest and southwest of Yunnan Province, good and medium zones were distributed in all parts of this province, poor zone was mainly distributed in center, southeast and northeast, while worse zone was mainly in northeast.

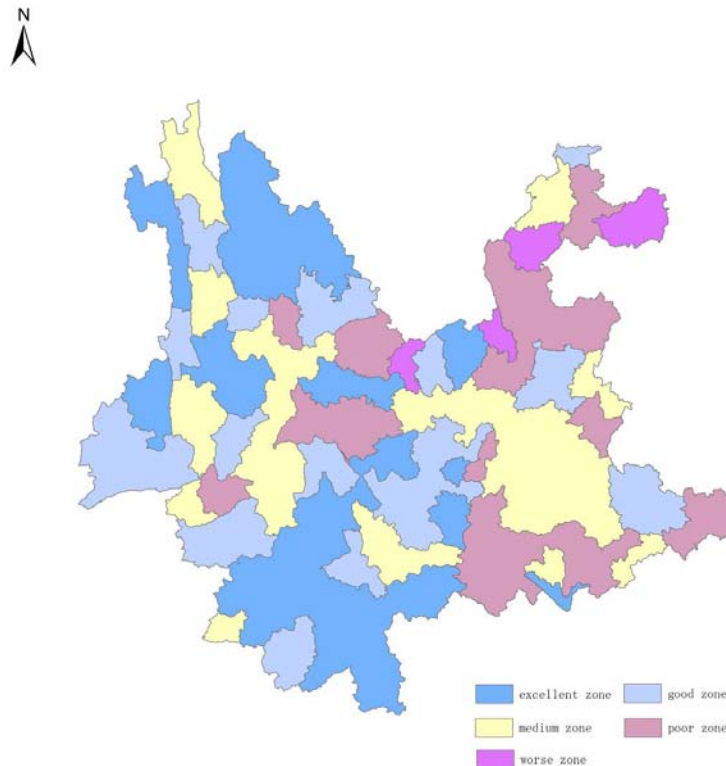


Figure 2 : Comprehensive evaluation of ecological environment situation in Yunnan province

When the eco-environment zones were overlaid with the results of arable land natural quality grade, it can get that, there were 3622 evaluation units in excellent zone with an area of 1095,998 hm², which accounted for 26.12% and 17.91% of the total units and area respectively. There were 3552 evaluation units in good zone with an area of 1337,564 hm², which accounted for 25.61% and 21.86% of the total units and area respectively. There were 3599 evaluation units in medium zone with an area of 1800,466 hm², which accounted for 25.92% and 29.42% of the total units and area respectively. There were 2749 evaluation units in poor zone with an area of 1515,457 hm², which accounted for 19.82% and 24.76% of the total units and area respectively. There were 346 units in the worse zone with an area of 370,065 hm², which accounted for 2.49% and 6.05% of total units and area respectively. Except for the worse zone, the number of evaluation units in other zones was almost the same. The total area of arable land in medium zone was the largest. The average area of each unit in poor zone was the largest with an area of 1,069 hm² per unit, while that in excellent zone was the smallest with an area of 302 hm² per unit.

Distribution characteristics of arable land natural quality grade in excellent zone

The grades of arable land natural quality ranged from 2 to 21, plus 25 and 26 in excellent zone. From Figure 3, it can be seen that the distribution of arable land was partial normal, and the area- weighted average grade was 9.3. Among them, the area of grade 6 arable land was the largest with an area of 186,717 hm², and accounted for 17.04% in the zone. The area of grade 2 arable land was the smallest with an area of 108 hm², and accounted for 0.01%. The distribution characteristics of arable land natural quality grade in this zone was similar to that of the whole province's, which was mainly concentrated in the grade of 4-18, and the total area was 1069,175 hm², which accounted for 97.55%.

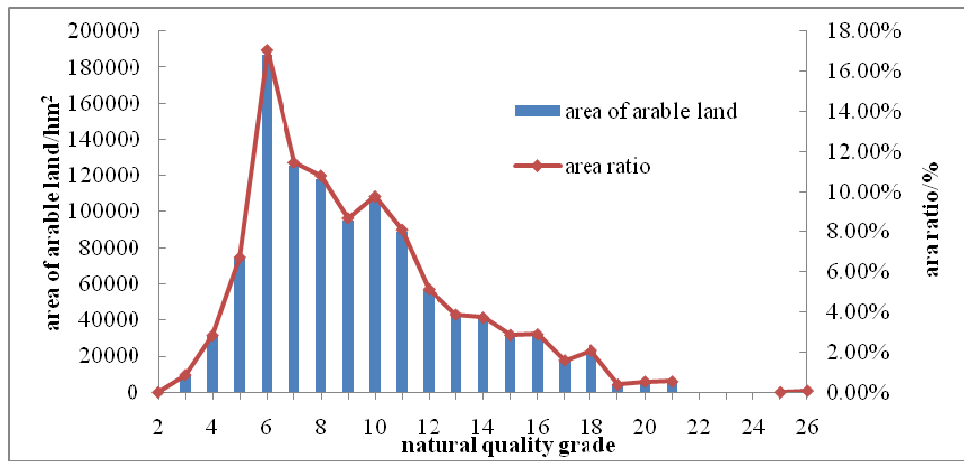


Figure 3 : Structure of arable land grade in excellent zone

Distribution characteristics of arable land natural quality grade in good zone

The grades of arable land natural quality ranged from 3 to 23, plus 1 in good zone. From Figure 4, it can be seen that the distribution of arable land was partial normal, and the area- weighted average grade was 10.3. Among them, the area of grade 9 arable land was the largest with an area of 210,241 hm², and accounted for 15.72% in the zone. The area of grade 1 arable land was the smallest with an area of 998 hm², and accounted for 0.07%. The distribution characteristic of arable land natural quality grade in this zone was mainly concentrated in the grade of 5-20, and the total area was 1314.129 hm², which accounted for 98.25%.

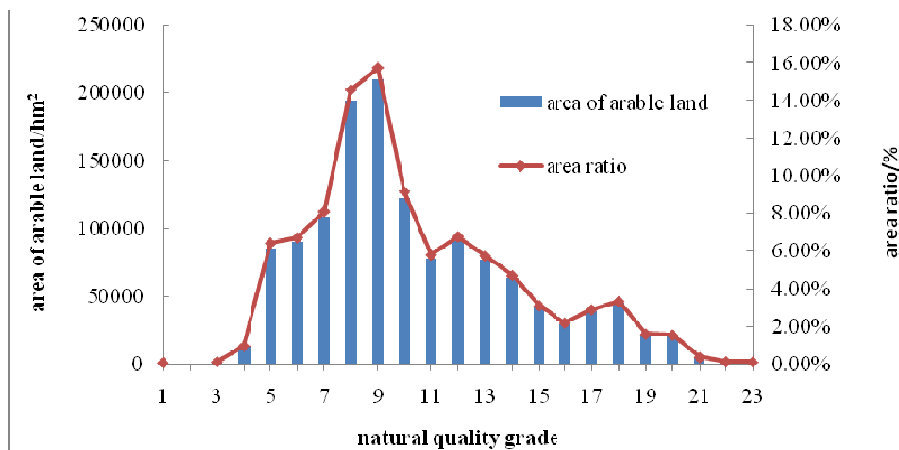


Figure 4 : Structure of arable land grade in good zone

Distribution characteristics of arable land natural quality grade in medium zone

The grades of arable land natural quality ranged from 2 to 25 in medium zone. From Figure 5, it can be seen that the distribution of arable land was partial normal, and the area- weighted average grade was 10.4. The area of arable land among 8-11 is relatively close, and the area of grade 11 arable land was the largest with an area of 238,006 hm², which accounted for 13.32%. The area of grade 3 arable land was the smallest with an area of 1,723 hm², and accounted for 0.10%. The distribution characteristic of arable land natural quality grade in this zone was mainly concentrated in the grade of 5-17, and the total area was 1736,307 hm², which accounted for 96.44%.

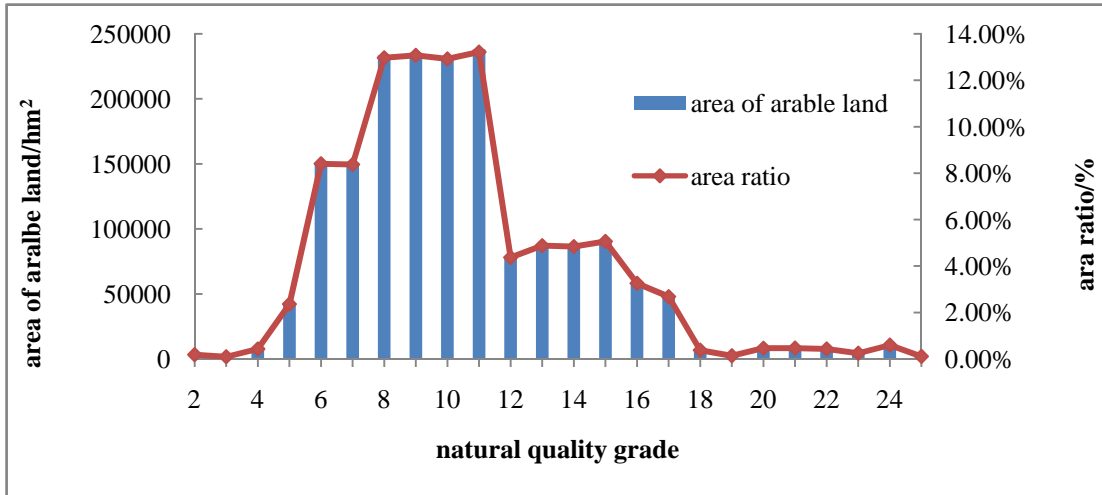


Figure 5 : Structure of arable land grade in medium zone

Distribution characteristics of arable land natural quality grade in poor zone

The grades of arable land natural quality ranged from 4 to 28 in poor zone. From Figure 6, it can be seen that the distribution of arable land was partial normal, and the area- weighted average grade was 9.6. Among them, the area of grade 9 arable land was the largest with an area of 157,341 hm², which accounted for 16.98%. The area of grade 28 arable land was the smallest with an area of about 4 hm², and accounted for almost 0. The distribution characteristic of arable land natural quality grade in this zone was mainly concentrated in the grade of 5-17, and the total area was 1485,149 hm², which accounted for 98.00%.

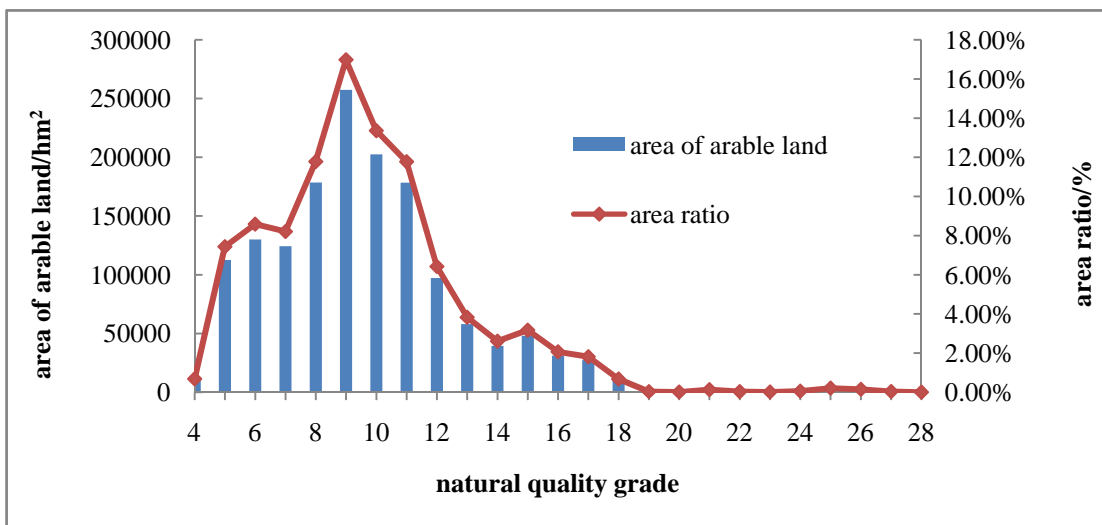


Figure 6 : Structure of arable land grade in poor zone

Distribution characteristics of arable land natural quality grade in worse zone

The grades of arable land natural quality ranged from 4 to 28 without 17-19 in worse zone. From Figure 7, it can be seen that the distribution of arable land was partial normal, and the area- weighted average grade was 8.1. Among them, the area of grade 8 arable land was the largest with an area of 114,563 hm², which accounted for 30.96%. The area of grade 13 arable land was the smallest with an area of about 4 hm², and accounted for almost 0. The distribution characteristic of arable

land natural quality grade in this zone was mainly concentrated in the grade of 3-11, and the total area was 352,824 hm², which accounted for 95.34%.

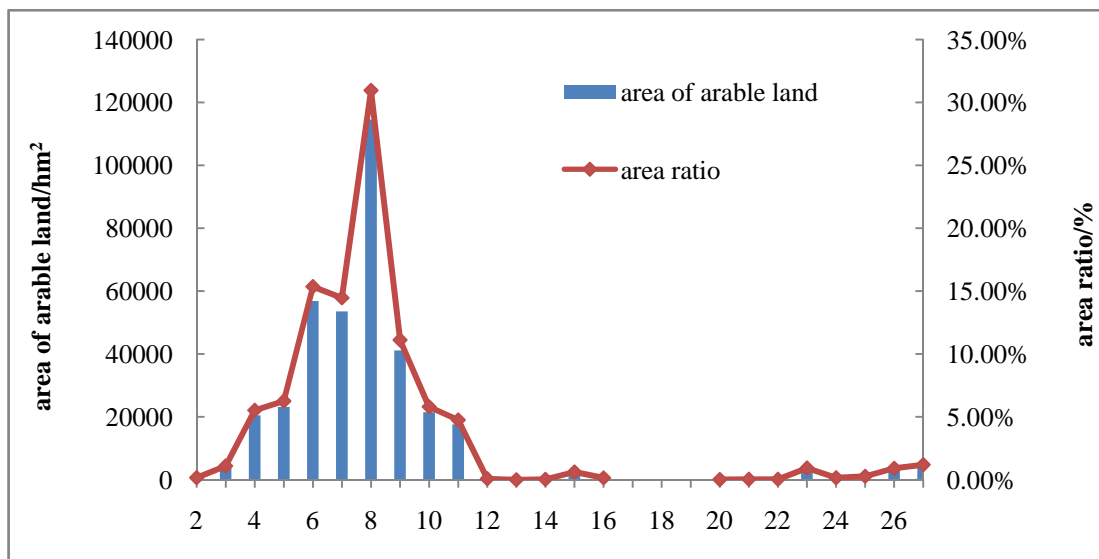


Figure 7 : Structure of arable land grade in worse zone

Relationship among arable land natural quality grades in eco-environment zones

The distribution of arable land natural quality was partial normal in each eco-environment zone according to the analysis mentioned above, and dominated by intermediate and low grade arable land. The arable land natural quality grade was analyzed by the way of horizontal, vertical and comprehensive comparison among different eco-environment zones as can be seen in TABLE 1

	excellent zone		good zone		medium zone		poor zone		worse zone		total average grade
	area of arable land /hm ²	average grade	area of arable land /hm ²	average grade	area of arable land /hm ²	average grade	area of arable land /hm ²	average grade	area of arable land /hm ²	average grade	
superior	1117.47	25.8	3101.54	22.5	25123.43	23.3	7288.28	25.1	13056.81	25.3	24.1
advanced	119696.28	16.8	200142	17.3	224377.97	16.2	119429.67	16.1	3113.27	15.6	16.6
intermediate	548594.96	10.3	835148.19	10.2	1193429.3	10.3	1011454.8	10.1	195227.55	8.7	10.1
low	426589.31	5.9	299172.04	6	357535.87	6.2	377284.74	6	158667.78	5.8	6
total	1095998.02	9.3	1337563.77	10.3	1800466.57	10.4	1515457.51	9.6	370065.41	8.1	9.8

Horizontal analysis of arable land natural quality grade in eco-environment zones

Horizontal analysis is for arable land natural quality in the same grade scale, but in different eco-environment zones.

The area ratio of arable land in excellent zone, good zone, medium zone, poor zone and worse zone was 2.25%, 6.24%, 50.56%, 14.67% and 26.28% respectively in the scope of superior grade. From the view of average natural quality grade of the superior, it was the lowest in good and medium zone, while the difference of that among others was small, and the total average grade was 24.1. The ratio in excellent zone, good zone, medium zone, poor zone and worse zone was 17.95%, 30.02%, 33.65%, 17.91% and 0.47% respectively in the scope of advanced grade. From the view of average natural quality grade of the advanced, it was the highest in good zone and the lowest in worse zone, while the difference of that among others was small, and the total average grade was 16.6. The ratio in excellent zone, good zone, medium zone, poor zone and worse zone was 14.50%, 22.07%, 31.54%, 26.73and 5.16% respectively in the scope of intermediate grade. From the view of average natural quality grade of the intermediate, it was nearly the same except that in worse zone, and the total average grade was 10.1. The ratio in excellent zone, good zone, medium zone, poor zone and worse zone was 26.34%, 18.48%, 22.08%, 23.30% and 9.80% respectively in the scope of low grade. From the view of average natural quality grade of the low, it was almost the same, and the total average grade was 6.

Vertical analysis of arable land natural quality grade in eco-environment zones

Vertical analysis is for arable land natural quality in different grades, but in the same eco-environment zone.

The area ratio of the superior grade, the advanced grade, the intermediate grade and the low grade was 0.10%, 10.92%, 50.05% and 38.92% respectively in the excellent zone. Because both the ratio of the intermediate and low grade were relatively larger, it made the grade of the whole excellent zone tend to moderate, which was 9.3. The area ratio of the superior grade, the advanced grade, the intermediate grade and the low grade was 0.23%, 14.96%, 62.44% and 22.37% respectively in the good zone. Because the ratio of the intermediate grade was relatively larger, it made the grade of the whole good zone tend to moderate, whose grade 10.3. The area ratio of the superior grade, the advanced grade, the intermediate grade and the low grade was 1.40%, 12.46%, 66.28% and 19.86% respectively in the medium zone. Because of the same reason that the ratio of the intermediate grade was relatively larger, it made the grade of the whole medium zone tend to moderate, whose grade was 10.4. The area ratio of the superior grade, the advanced grade, the intermediate grade and the low grade was 0.48%, 7.88%, 66.74% and 24.90% respectively in the poor zone. Because of the same reason that the ratio of the intermediate grade was relatively larger, it made the grade of the whole poor zone tend to moderate, whose grade was 9.3. The area ratio of the superior grade, the advanced grade, the intermediate grade and the low grade was 3.53%, 0.84%, 52.75% and 42.88% respectively in the worse zone. Because both the ratio of the intermediate and low grade were relatively larger, it made the grade of the whole worse zone tend to lower moderate, whose grade was 8.1.

Comprehensive analysis of arable land natural quality grade in different eco-environment zones

Comprehensive analysis was to combine horizontal and vertical analysis together, whose results could show the whole distribution of arable land through the degree of correlation and coordination effect in Yunnan Province.

The natural eco-environment in excellent zone was best just because of the higher forest coverage rate and lower population density. However, these conditions did not impact on the quality of arable land a lot. Meanwhile, there were many valleys in the zone, and the vertical terrain changed significantly, which had much greater influence on the quality of arable land. As a result, the average natural quality grade in this zone was lower than that in the whole province^[21]. Good zone and medium zone were distributed within the province, but the amount of arable land in medium zone was larger than that in good zone, so the whole quality in medium zone was better from the view of area-weighted average grade, and both grade of the two zones was higher than that of the whole province. The average natural quality grade in poor zone and worse zone was lower than that of the whole province, between which, that in worse zone was the worst. One was that karst topography was the dominant characteristic in these zones, which meant that the rich rain resource could not transfer into the natural condition of arable land well enough. The other reason was that the population density so large that it caused excessive exploitation and use of arable land. Arable land in these zones were dominated by scattered slope ones, which aggravated soil erosion and the contradiction between human being and nature.

CONCLUSION

(1) It analyzed the properties of arable land quality grade, and explained the spatial distribution of that based on the accomplishment of cultivated land classification within 129 counties in Yunnan Province.

(2) The natural quality grade of arable land was lower as a whole, and its average grade was 9.8. Arable land natural quality grade was dominated by that ranged from grade 4 to 18 in this region, which accounted for 97.44%.

(3) The area of intermediate grade arable land was the largest, which accounted for 61.83%. While that of superior grade arable land was the smallest, which accounted for only 0.81%.

(4) There were differences of distribution of arable land among eco-environment zones, and the grade in medium zone was the highest, grade 10.4, while that in worse zone was the lowest, grade 8.1.

This paper analyzed the distribution differences of arable land in Yunnan Province from the macro aspect, however, the deep relationship between quality grade distribution and eco-environment, and also the policy that how to guide the land exploitation and protection need to be further research.

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