

# Research on the spatial distribution characteristics of arable land economic quality composite grade and ecology environment in Yunnan Province, China

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## ABSTRACT

*Understanding the distribution characteristics of arable land in Yunnan Province is of significant importance to make scientific decisions to use and improve the 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 economic quality composite grade was 2.9, in a range of 1 to 13, which means that the economic quality of arable land of Yunnan Province is relatively lower. In excellent zone, the grade ranges from 1 to 10, and the average grade is 2.4. In good zone, it ranges from 1~13, and the average grade is 3.1. In medium zone, it ranges from 1~12, and the average value is 3.2. In poor zone, it ranges from 1~11, and the average is 3. In worse zone, it ranges from 1~10, and the average is 2.2. The middle and poor arable land has the largest area, which concentrated in the middle and poor zones and dominantly influenced the average grade in the whole province. This research will serve as a reference for arable land policy making in the future, especially on space arrangement optimization, quality improvement and ecology environment protection in Yunnan Province.*

**Key words:** arable land, economic quality composite grade, distribution, ecological environment, Yunnan Province

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## INTRODUCTION

Arable land is as an important carrier for human and social development and very closely related to human survival and development. Economic quality composite grade of arable land could be used as a parameter to study the influence from human factors, and affects social stability and sustainable development<sup>[1]</sup>. To prepare the implement "Land Management Law of People's Republic of China", which requires scientific, rational, unified, strict management of cultivated land resources, improved management level of arable land resources, and to provide scientific basis for land use planning and land use management, Yunnan Province has been carrying out province-wide arable land quality evaluation since 2004, and agricultural land classification work was accomplished in this background<sup>[2-4]</sup>. Yunnan agricultural land classification is an investigation implemented to evaluate arable land quality of the province with unified technical specifications and is based on county-level administrative regions. The results can fully reflect natural conditions of arable land, which provides accurate arable land quality information for land and resources administration<sup>[5-8]</sup>.

Yunnan province is the region with most severe conflicts between people and land, which typically exists in ecologically fragile and less developed region. With the current urbanization process, the protection of arable land resources of the region face greater pressure. Starting from the province of spatial pattern, the understanding of distribution characteristic of arable land and will provide a basis to determine scientific measures for the quality improvement and protection of arable land is needed. This study on the distribution of arable land economic quality composite grade is mainly based on natural conditions of arable land, economic quality grade, production capacity, etc. less in combining economic quality composite grade and status of ecologic environment<sup>[9-16]</sup>. Based on agricultural land classification results and the combined evaluation results of ecological environment of Yunnan Province, this study analyzed spatial distribution characteristics of economic quality composite grade of the province's arable land, with a view to provide a

basis for differentiated arable land use and protection policy.

### 1 General Background of the Study Area and Data Sources

#### General Background of the Study Area

Located in the southwest of China, Yunnan Province borders Asian mainland in the North, and connects Southeast Asia Peninsula in the south. Under control of southeast and southwest monsoons, its environment is also affected by Tibetan Plateau, presenting a complex and diverse natural geographical environment. Yunnan administrative district now consists of 16 cities, 129 counties (cities, districts), and has a total land area of 394,000 square kilometers. Among them, arable land accounts for 15.97% of the province, garden plot 2.12%, forest area 57.69%, grassland 2.05%.

Yunnan province is of mountain plateau terrain dominant by mountainous regions. The province's terrain is higher in the northwest, lower in southwest and southeast. With undulating terrain, it is alternatively distributed with mountains, plateaus, basins and valleys, forming a complex and diverse landform. Mountains, hills and intermountain basins are the main landform, in which mountains account for 84% of the total area of the province, hills account for around 10%, intermountain basins account for the rest 6%. Arable land is mainly distributed in basins and mountainous areas. Sloping farmland accounts for 64% of total arable land and are fragmentarily scattered with serious soil erosion and low production capacity<sup>[17]</sup>.

#### Data Sources

Provincial summary results of agricultural land classification of 129 counties (cities, districts) in Yunnan Province plus status evaluation results of ecological environment in Yunnan Provincial comprehensive remote sensing project of territorial resources are taken as the data base of this study. According to the provincial classification achievements, arable land economic quality composite grade increases and becomes better as figures increase.

## DATA PROCESSING AND ANALYSIS METHOD

### Data Processing Method

Provincial summary database of agricultural land classification in the province's 129 counties (cities, districts) is taken as data base for the analysis. Spatial overlay analysis is performed by combining integrated remote sensing survey data of Yunnan Provincial territorial resources with ArcGIS as spatial analysis platform. And differentiation characteristics of provincial classification in space is analyzed.

Through the combination of mechanical input costs per unit area of farming, sowing, harvest; water, electricity, diesel fuel and other expenses per unit area; seeds, fertilizers, pesticides, plastic film and other costs per unit area, local labor costs, transportation costs for agricultural products, agricultural product prices in the provincial area, and following standard farming system, the index of arable land economic quality composite grade was calculated in accordance with comprehensive land economic coefficient under certain natural conditions, average land-use conditions, average land economic conditions. The calculation method for integrated land economic coefficient is described in the following formula.

$$Gi = Yi \cdot Kc = Ri \cdot Kl \cdot Kc \quad (1)$$

Wherein,  $Gi$  represents index of arable land economic quality composite grade of  $i$ -th classification unit;  $Yi$  represents arable land utilization index of  $i$ -th classification unit;  $Kc$  represents integrated land economic coefficient of classification unit in equivalence region;  $Ri$  represents arable land nature grade index of  $i$ -th classification unit;  $Kl$  represents integrated arable land utilization coefficient of classification unit in equivalence region. As shown in the equation, economic quality composite grade derives from utilization grade and nature grade, reflecting transitivity and correlation. So results of economic quality composite grade can better comprehensively represent objective quality of arable land.

In this study, to calculate the average economic grade within the region, the area weighted average method is adopted, which is under the premise that total area of various grades is calculated out, carry out area weighting of various grades<sup>[18-20]</sup>.

$$Y = \frac{\sum_{i=i_{\min}}^{i_{\max}} i \times S_i}{S_T} \quad (2)$$

In the formula,  $Y$  represents average economic quality composite grade of the area;  $i$  represents

economic quality composite grade of arable land;  $i_{\min}$  is the minimum grade;  $i_{\max}$  is the maximum grade;  $S_i$  represents agricultural acreage of  $i$ ,  $hm^2$ ;  $S_T$  represents total agricultural acreage of the region,  $hm^2$ .

### 2.2 Spatial Analysis

Agricultural land classification results of 129 counties (cities, districts) are taken as data base for the analysis. Spatial analysis capabilities of ArcGIS software was applied in this study, and the results are converted. With spatial overlay analysis, statistical analysis, comprehensive analysis and other analysis methods, distribution characteristics of arable land utilization in zone scale of status evaluation of ecological environment was analyzed.

## RESULTS AND ANALYSIS

### Quantitative Distribution Characteristics of Arable Land Economic Quality Composite Grades

According to the agricultural land classification results of Yunnan Province, arable land consisting of 13,868 provincial evaluation units has a total area of 6.1195 million  $hm^2$ . There are 13 grades in economic quality composite grade of arable land, ranging from 1 to 13, of which grade 1 represents the lowest economic level, and grade 13 represents the highest economic level. The average area weighted is 2.9. As shown in Figure 1, the economic quality composite grade of arable land of Yunnan Province has a typical skewed distribution, generally low in grades. Arable land of grade 2 has the highest number, accounting for 28.63%. While grade 13 has the minimum number, accounting for only 0.01%. The province's economic quality composite grade of arable land mainly is between 1~4, with a total area of 5257393.84  $hm^2$ , accounting for 85.91%. The arable land with economic quality composite grade between 5~13 is 865127.44  $hm^2$  in area, accounting for 14.09%.

Depending on the scope of the province's economic quality composite grade of arable land, the arable land was classified into four grades: poor (grade 1~3), medium (grade 4~6), higher (grade 7~9) and excellent (grade 10~13). Poor land in Yunnan province has an area of 4334891.09  $hm^2$ , accounting for 70.84% of the province's total cultivated area. Medium land is

1537868.62 hm<sup>2</sup>,accounting for 25.13%.Higher land is 222062.33 hm<sup>2</sup>,accounting for 3.63%;Excellent land is 24729.24 hm<sup>2</sup>,accounting for only 0.40%.

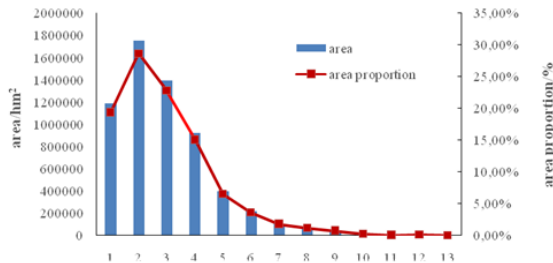


Figure 1. Structure of arable land economic quality composite grade in Yunnan Province

Distribution Characteristic of Arable Land Economic Quality Composite Grades on Ecological Environment Assessment Zone

According to Yunnan provincial territorial resources remote sensing integrated survey project, Yunnan Province satellite remote sensing data is taken as the information source, with dominant factor, regional differences,overall consideration and operability as selection principles of index, 6 indexes of forest coverage rate,water resources per square meter of soil, slope dryland proportion, proportion of unused land, soil erosion rate, population density are selected, and then ecological environment of the province is divided into five grades, i.e. excellent zone, good zone, medium zone, poor zone and worse zone<sup>[21,22]</sup>.Excellent ecological environment zone in Yunnan Province is mainly distributed in lake basin of central Yunnan plateau, mountains and canyons innorthwest Yunnan and broad valley insouthwest Yunnan. Good and medium zones are distributed throughout the whole province; while poor zone is mainly distributed inlake basin of

central Yunnan plateau,hilly plain insoutheastYunnan andmountain plateau innortheast Yunnan. The worse zone ismainly distributed inmountain plateau innortheast Yunnan.

As shown in Figure 2 and Table 1, Yunnan Province agricultural land classification results was overlapped with the province's ecological environment statuszone, from which it can be clearly seen that except worse zone, there isn't any significant differences in the number of evaluation units between each zone.The total area of arable land represents the majority in medium zone. Theaverage singleagricultural acreage in worse zone isthe most (1069.6hm<sup>2</sup> / block) .whileaverage singleagricultural acreage inexcellnt zone is the lowest (302.59hm<sup>2</sup> / block.)

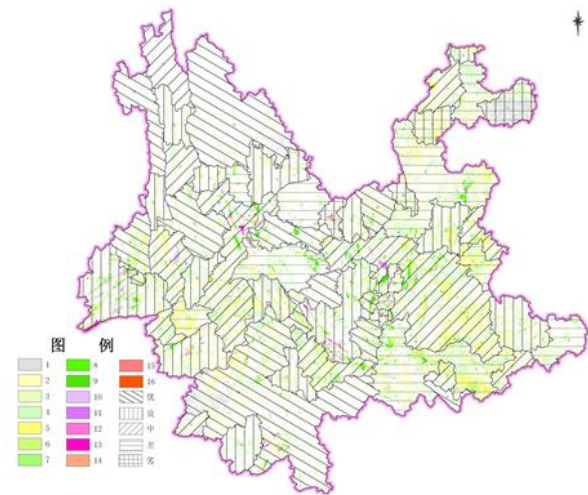


Figure 2. The overlapped chart of land economic quality composite grade and ecological environment in Yunnan Province

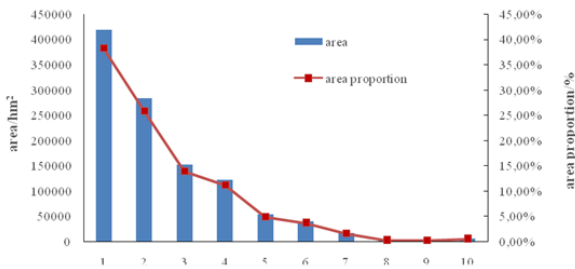
Table 1 - Overlay of land economic quality composite grade and ecological environment in Yunnan Province

	number	number per (%)	area (hm <sup>2</sup> )	area per (%)
excellent zone	3622	26.12%	1095998.02	17.91%
good zone	3552	25.61%	1337564	21.86%
medium zone	3599	25.92%	1800466.57	29.42%
poor zone	2749	19.82%	1515457.5	24.76%
worse zone	346	2.49%	370065.41	6.05%
total	13868	100%	6119551.5	100%

(1) Distribution Characteristic of Arable Land Economic Quality Composite Grade in Excellent Zone

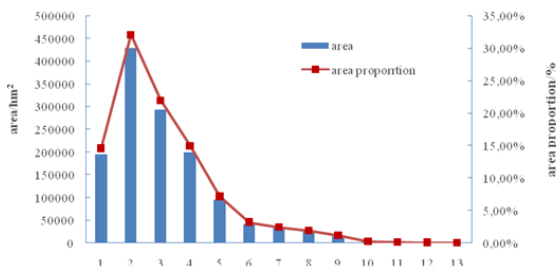
In present status of ecologic environment, arable land economic quality composite grade of excellent zone is distributed in therange of 1~10.

As shown in figure 3, distribution of arable land grade in the zone is of skewed normal distribution, and area weighted average grade is 2.41. The agricultural acreage of grade 1 has the highest area of 419053.61 hm<sup>2</sup>, accounting for 38.23%; and agricultural acreage of grade 9 has the lowest area of 2159.79 hm<sup>2</sup>, which is close to zero. Distribution of arable land economic quality composite grade of excellent zone is similar to that of provincial land economic quality composite grade, mainly in 1~ 4, with a total area of 976068.74 hm<sup>2</sup>, accounting for 89.06%.



**Figure 3.** The structure of arable land economic quality composite grade in excellent zone

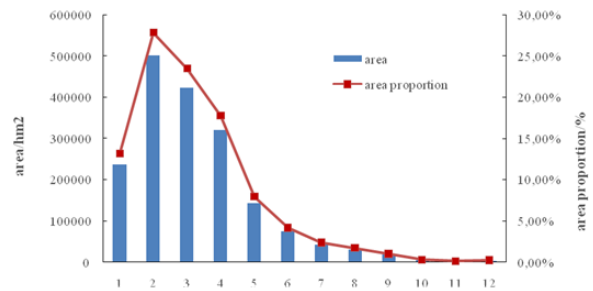
(2) Distribution Characteristic of Arable Land Economic Quality Composite Grade in Good Zone  
 In present status of ecologic environment, arable land economic quality composite grade of good zone is distributed in the range of 1~13. As shown in figure 4, distribution of arable land grade in the zone is of skewed normal distribution, and area weighted average grade is 3.1. The agricultural acreage of grade 2 has the highest area of 429233.32 hm<sup>2</sup>, accounting for 32.09 %; and agricultural acreage of grade 13 has the lowest area of 573.87 hm<sup>2</sup>, accounting for 0.04 %. Distribution of arable land economic quality composite grade of good zone is similar to that of provincial land economic quality composite grade, mostly in 1~ 4, with a total area of 1118926.23hm<sup>2</sup>, accounting for 83.65%.



**Figure 4.** The structure of arable land economic quality composite grade in good zone

(3) Distribution Characteristic of Arable Land Economic Quality Composite Grade in Medium Zone

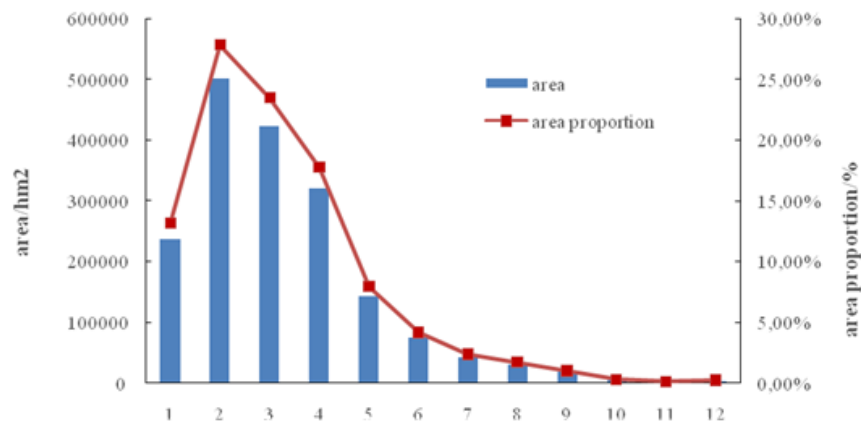
In present status of ecologic environment, arable land economic quality composite grade of medium zone is distributed in the range of 1~12. As shown in figure 5, distribution of arable land grade in the zone is of skewed normal distribution, and area weighted average grade is 3.2. The agricultural acreage of grade 2 has the highest area of 500816.99hm<sup>2</sup>, accounting for 27.82 %; agricultural acreage of grade 11 has the lowest area of 2124.22hm<sup>2</sup>, accounting for 0.12 %. Distribution of arable land economic quality composite grade of medium zone is similar to that of provincial land economic quality composite grade, mostly in 1~ 4, with a total area of 1480013.05hm<sup>2</sup>, accounting for 82.20 %.



**Figure 5.** The structure of arable land economic quality composite grade in medium zone

(4) Distribution Characteristic of Arable Land Economic Quality Composite Grade in Poor Zone

In present status of ecologic environment, arable land economic quality composite grade of poor zone is distributed in the range of 1~11. As shown in figure 6, distribution of arable land grade in the zone is of skewed normal distribution, and area weighted average grade is 3.0. The agricultural acreage of grade 2 has the highest area of 435080.44 hm<sup>2</sup>, accounting for 28.71 %; agricultural acreage of grade 11 has the lowest area of 6.09 hm<sup>2</sup>, close to 0. Distribution of arable land economic quality composite grade of poor zone is similar to that of provincial land economic quality composite grade, mostly in 1~ 4, with a total area of 1323182.56 hm<sup>2</sup>, accounting for 87.31 %.

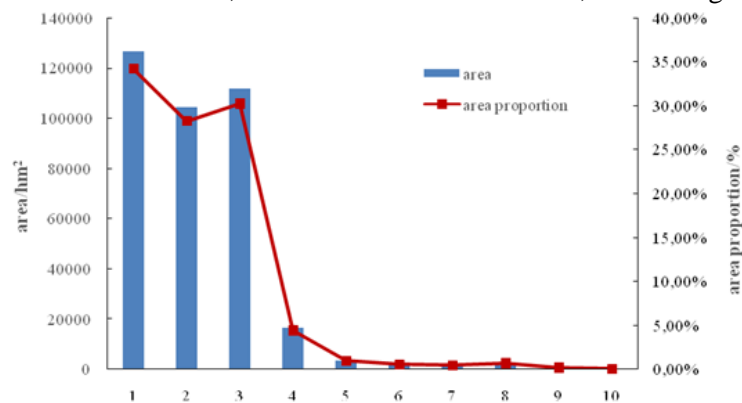


**Figure 6** - The structure of arable land economic quality composite grade in poor zone

#### (5) Distribution Characteristic of Arable Land Economic Quality Composite Grade in Worse Zone

In present status of ecologic environment, arable land economic quality composite grade of poor zone is distributed in the range of 1~10. As shown in figure 7, distribution of arable land grade in the zone is of skewed normal distribution, and area

weighted average grade is 2.2. The agricultural acreage of grade 1 has the highest area of 126474.8 hm<sup>2</sup>, accounting for 34.28 %; agricultural acreage of grade 10 has the lowest area 235.41 hm<sup>2</sup>, accounting for 0.06 %. Distribution of arable land economic quality composite grade of worse zone is mainly between 1~3, with a total area of 342889.23 hm<sup>2</sup>, accounting for 92.66 %.



**Figure 7** - Structure of arable land economic quality composite grade in worse zone

#### Arable Land Economic Quality Composite Grade in Ecological Environmental Evaluation Zone

According to analysis of arable land economic quality composite grade in Yunnan in status zone of ecologic environment, arable land economic quality composite grade in each ecological zone is of skewed normal distribution, mainly land in

medium and low grade. Take arable land economic quality composite grade as the research focus, conduct horizontal and vertical analysis and comprehensive analysis in different ecological zones. See below for the details.

**Table 2.** The average economic quality composite grade of arable land in different ecological environment zones in Yunnan Province

	Excellent zone		Good zone		Medium zone		Poor zone		Worse zone		Average grade in summary
	Agricultural acreage /hm <sup>2</sup>	Average grade	agricultural acreage /hm <sup>2</sup>	Average grade	agricultural acreage /hm <sup>2</sup>	Average grade	agricultural acreage /hm <sup>2</sup>	Average grade	agricultural acreage /hm <sup>2</sup>	Average grade	
Excellent land	0	--	6230.81	10.9	11331.57	10.9	1431.73	10	235.41	10	10.8
Higher land	21321.21	7.3	73391.19	7.8	91125.21	7.7	31222.42	7.8	5002.3	7.8	7.7
Medium land	215306.05	4.6	339005.68	4.5	537736.98	4.5	423881.45	4.5	21938.47	4.4	4.5
Poor land	853871.05	1.7	918936.1	2.1	1160272.8	2.2	1058921.91	2.2	342889.23	2	2.1
Summery	1090498.31	2.4	1337563.78	3.1	1800466.56	3.2	1515457.51	3	370065.41	2.2	2.9

#### (1) Horizontal Analysis of Arable Land Economic Quality Composite Grade in Various Ecological Environment Zones

Horizontal analysis is to analyze arable land economic quality composite grade in the same grade range but in different ecological environment zones.

Within the range of excellent land, arable land area percentage of excellent zone, good zone, medium zone, poor zone and worse zone are 0, 32.40%, 58.93%, 7.45% and 1.22% respectively; As seen from average economic quality composite grade of excellent land, there is no excellent land in excellent zone. The average economic quality composite grade of good and medium zone is the most. While in other ecological zones they have little difference and average economic quality composite grade in summary is 10.8. In the range of higher land, arable land area percentages of excellent zone, good zone, medium zone, poor zone and worse zone are 9.60%, 33.05%, 41.04%, 14.06% and 2.25% respectively. In the perspective of average economic quality composite grade, good zone, medium zone, poor zone and worse zone are essentially the same, The excellent zone is the lowest, with average economic quality composite grade of 7.7. Within the range of medium land, arable land area percentage of excellent zone, good zone, medium zone, poor zone and worse zone are 14.00%, 22.04%, 34.97%, 27.56% and 1.43% respectively. In the perspective of average economic quality

composite grade, various ecological zones are basically the same, and the total average economic quality composite grade is 4.5. Within the range of poor land, arable land area percentage of excellent zone, good zone, medium zone, poor zone and worse zone are 19.70%, 21.20%, 26.77%, 24.43% and 7.91% respectively. From the view of average economic quality composite grade, a good zone, medium zone, poor zone and worse zone are basically the same, comparatively lower excellent zone is slightly whose average economic quality composite grade in summary is 2.1.

#### (2) Vertical Analysis of Arable Land Economic Quality Composite Grade in Various Ecological Environment Zones

Vertical analysis is to analyze arable land economic quality composite grade in different grade ranges and in the same ecological environment zone.

In the excellent zone, area percentages of excellent land, higher land, medium land and poor land are 0, 1.96%, 19.79% and 78.30% respectively. As area of poor land contributes the most, the average economic quality composite grade of arable land in the entire excellent zone tends to be low with grade of 2.4. In good zone, area proportions of excellent land, higher land, medium land and poor land are 0.47%, 5.49%, 25.35% and 68.70% respectively.,

As poor land is the majority, the average economic quality composite grade of arable land in the entire good zone is also low, with an average economic quality composite grade of 3.1, which is middle or slightly low. In medium zone, area percentage of excellent land, higher land, medium land and poor land are 0.63%, 5.06%, 29.87% and 64.44% respectively. poor land is largest proportion. So the average economic quality composite grade of arable land in the zone tends to be middle or slightly low with grade of 3.2. In poor zone, area percentage of excellent land, higher land, medium land and poor land are 0.09%, 2.06%, 27.97% and 69.87% respectively. In which poor land is still the one that affects average economic quality composite grade. As a result, the overall average economic quality composite grade also tends to be low, with a grade of 3. In worse zone, area percentage of excellent land, higher land, medium land and poor land are 0.06%, 1.35%, 5.93% and 92.66% respectively. The poor land also contributes the most to the average economic quality composite grade of arable land so its average grade is low with a grade of 2.2.

### (3) Comprehensive Analysis of Arable Land Economic Quality Composite Grade in Various Ecological Environment Zones

By combining vertical and horizontal analysis of arable land economic quality composite grade in various ecological environment zones, the overall distribution of arable land quality in Yunnan Province can be reflected by the degree of correlation and coordination effect

Despite excellent zone has the best natural ecological environment, it is mainly distributed in the valleys which commonly are the gathering places of ethnic minorities, so the agricultural technology and production input per unit area is relatively low. Their low level of industrialization and irrational industrial structure negatively impacts economic factors of arable land, as a result the overall average economic quality composite grade is lower than the provincial average grade<sup>[23]</sup>. Good zone and medium zone are distributed throughout the province, of which, arable land is more distributed in flatland region and valley area with the best light, heat, water, and soil conditions. Social economy is the most developed with the highest planting level. Although number of arable land of different grades in medium zone is slightly higher than that in good zone, seen from area weighted average, the

overall quality of arable land in medium zone and in good zone are equivalent, both of which has higher average economic quality composite grade than the provincial average grade. Poor zone and worse zone are mainly concentrated in Southeast, Northeast Yunnan. On the one hand, there is much limestone in the zone, with sloping farmland and dry land as the main, which limits investment and management of arable land utilization conditions. On the other hand, the zone has large population density and single cropping system. In comparison, natural conditions and ecological environment of worse zone is worse, in terms of water conservancy, transportation and other infrastructure, labor quality is generally. As a result, arable land average economic quality composite grade of worse zone is lower than the provincial average grade.

## CONCLUSIONS AND DISCUSSIONS

(1) Treating Yunnan Province as a whole, this study comprehensively applied agricultural land classification data of 129 counties (cities) to analyze the province's characteristics of arable land economic quality composite grade, and explained the spatial distribution characteristics of arable land economic quality composite grade.

(2) Overall the arable land economic quality composite grade of Yunnan Province is relatively low, with an average economic quality composite grade of 2.9. The province's arable land economic quality composite grade is mainly in the range of 2-6, which represents 82.30% in total.

(3) Poor land, which represents 70.90% of the province's arable land, accounts for the largest proportion, while excellent land has the smallest area and only accounts for 0.31%.

(4) Differences exist in the distribution of arable land economic quality composite grade in ecological environment zones. Overall, arable land grade of medium zone is slightly higher with a grade of 3.2; and the worse zone is the lowest, grade

This paper conducted a combined analysis of distribution of arable land economic quality composite grade and ecological environment zones in Yunnan Province from a macro perspective. County-level administrative unit was used in this study as the evaluation units in Yunnan ecological environment zoning, which provides new ideas for joint analysis of arable land economic quality



composite grade and ecological environment zone. On the other hand, further studies may be conducted in the future unveil the linkages between distribution of arable land economic quality composite grade and ecological environment zones in Yunnan Province factors influencing arable land economic quality composite grade reasons explaining the differences in arable land economic quality composite grade and how to specifically guide future land utilization and protection.

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## REFERENCES

- [1] Peng Jian, Jiang Yijun, Liu Song. Progress and Prospects of Agricultural Land Classification Research in China [J]. Chinese Journal of Eco-Agriculture, 2005, 13 (4): 167-170.
- [2] Zhang Yaowu, Yu Jianxin. Investigation and Evaluation of Arable Land Quality Grade in China (Yunnan Volume) [M]. Beijing: China Land Press, 2010.
- [3] Kong Xiangnin, Zhang Qingpu. Spatial Distribution Characteristics of Arable Land Grade in China's Western Region [J]. Transactions of the Chinese Society of Agricultural Engineering, 2012, 28 (22): 1-7.
- [4] Yan Ning, Zheng Honggang, Yu Jianxin, et al. Study on Provincial Data Collection Method of Yunnan Agricultural Land Classification [J]. China Land Science, 2009, 32 (8): 31-35.
- [5] Yan Ning, Zheng Honggang, Yu Jianxin, et al. Study on Applying Agricultural Land Classification in Basic Farmland Division [J]. Territory & Natural Resources Study, 2009, 21 (03): 28-30.
- [6] Wang Bo, Zheng Honggang, Liu Shuxia, et al. Study on Applying Yunnan Province Agricultural Land Classification Results in Basic Farmland Protection [J]. Journal of Yunnan Agricultural University, 2009, 24 (1): 100-103.
- [7] Peng Errui, Wang Sui, Hao Lisha, et al. Study on Protection Status and Countermeasures of Arable Land and Basic Farmland in Yunnan Province [J]. Resources & Industries, 2009, 11 (4): 59-63.
- [8] Si Zhenzhong, Li Mao, Qiu Weili et al. Regional Differences and Protection of Arable Land Resources in China [J]. Journal of Natural Resources, 2010, 25 (5): 713-721.
- [9] Wang Hongbo, Cheng Feng, Zhang Zhongfan et al. Differentiation Characteristics of Chinese Arable Grade and Their Impact on Arable Land Protection [J]. Transactions of the Chinese Society of Agricultural Engineering, 2011, 27 (11): 1-8.
- [10] Liu Yuwang, Wang Bo. Study on Regional Distribution Law of Yunnan Agricultural Land Utilization Grade [J]. Resources & Industries, 2008, 10 (5): 83-87.
- [11] Zhang Qingpu, Kong Xiangbin, Yun Wenju. Grade Distribution Law of Chongqing City Before and After National Agricultural Land Classification Summary [J]. Transactions of the Chinese Society of Agricultural Engineering, 2010, 26 (10): 297-303.
- [12] Ren Kui, Zhou Shenglu, Zhang Hongfu, et al. Study on Spatial Pattern and Influence Mechanism of Jiangsu Farmland Resources Quality [J]. Transactions of the Chinese Society of Agricultural Engineering, 2008, 24 (4): 127-134.
- [13] Xu Yan, Wu Kening, Cheng Xianjun. Analysis of Productivity Spatial Variation Law and Leading Factor of Productivity Increase of Northeast Arable Land [J]. Resources Science, 2011, 33 (11): 2030-2040.
- [14] Jia Shu Hai, Qiu Zhiwei, Pan Jinhua, et al. Spatial Distribution and Influencing Factors of Liaoning Province Agricultural Land Quality [J]. Chinese Journal of Soil Science, 2011, 42 (2): 273-279.
- [15] Cui Xuhui. Distribution Characteristics of Gansu Agricultural Land Economic Quality and Cause Analysis [J]. Modern Business, 2013, 5 (16): 90-92.
- [16] Zhao Youchen. Agricultural Land Economic Quality Assessment and Spatial Distribution Research - with Anhui Province as an Example [J]. Rural Economy and Science-Technology, 2014, 20 (8): 19-21.
- [17] Wang Bo. Study on Spatial Distribution Law of Agricultural Land Utilization Grade in Broad Valley Area of Southern Yunnan [D]. Yunnan Agricultural University, 2008.
- [18] TD / T 1004-2003, Agricultural Land Classification Regulations [S].
- [19] Zhang Fengrong, Xu Yan, Zhang Jinke et al. Theory, Methods and Practice of Classification and Appraisal of Agricultural Land [M]. Beijing: China Agricultural University Press, 2008.
- [20] Yun Wenju. Chinese Arable Land Classification and Monitoring Studies [M]. Beijing: China Land Press, 2010.
- [21] Xu Jing, Fu Baohong. Ecological Environment Assessment of Yunnan [J]. Ecological Economy, 2002, 25 (7): 45-49.
- [22] Meng Guangtao, Fang Xiangjing, He Liping, et al. Ecological Environment Status Quo of Yunnan Province and Countermeasures [J]. Research of Soil and Water Conservation, 2006, 13 (2): 7-10.
- [23] Zou Yue, Fan Yi, Zheng Honggang. Study on Influence of Altitude Factors on Agricultural Land

Utilization Index[J] Yunnan Agricultural  
University, 2009,24 (2): 274-277.

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