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## Comprehensive Evaluation of Geological Environment Carrying Capacity for Lintong District, Xi'an

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# Comprehensive Evaluation of Geological Environment Carrying Capacity for Lintong District, Xi'an

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**Abstract.** Geological environment carrying capacity is one of the standards that judges the human activities and geological environment whether or not compatible. Carrying out geological environment carrying capacity evaluation and adjusting human activity intensity is the key to achieve sustainable development of regional economy. Based on the variation coefficient method, the paper used the comprehensive evaluation model to evaluate the geological environment carrying capacity of Lintong district, Xi'an. The results show that the carrying capacity of 4 sub-districts excellent, 7 sub-districts is good, 8 sub-districts is medium, and 4 sub-districts is poor. The results can provide references for the development of study area, and achieve the goals of making full use of land resources, regulating the geological environment changing trend and reducing disasters.

## 1. Introduction

Geological environment carrying capacity (GECC) is derived from environmental carrying capacity and is an important part of it [1]. GECC reflects the dialectical relationship between human activities and geological environment, and establishes the link between human activities and geological environment [2]. In 1992, William et al. proposed to use the ecological footprint method to evaluate the GECC by comparing the size of ecological footprint on the level of supply and demand. In 2003, Wackemagel et al. improved further the ecological footprint method [3, 4]. In 2004, Garry et al. evaluated the GECC of New Zealand based on ecological footprint method [5]. In 2008, Yu zhishan et al. improved the concept, characteristics and connotation of the GECC by taking the urban GECC evaluation as an example [6]. In 2014, Ren guangyuan et al. studied the GECC of Ningxia Yanhuang economic zone by 3S technology [7].

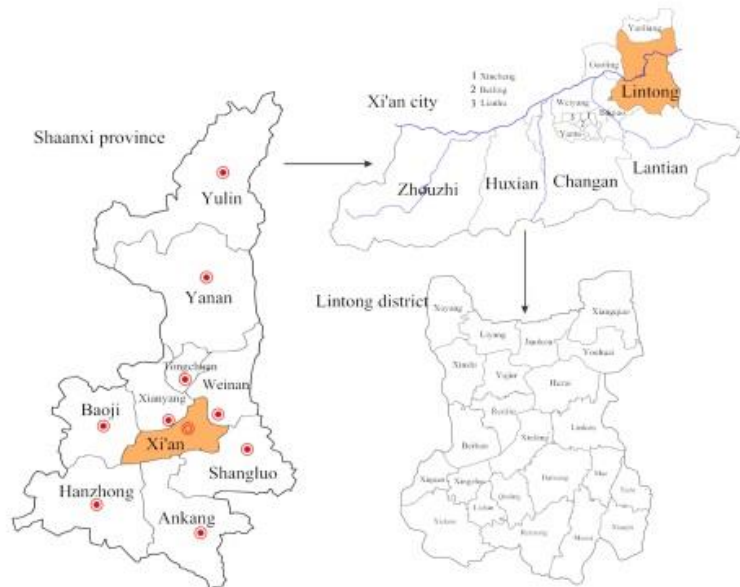
Generally, the domestic and foreign scholars have achieved fruitful results on geological environment bearing capacity. However, small regions (such as districts and counties) are not involved and the classification of larger regions is not accurate. The paper takes Lintong district as the study area and evaluates the GECC of study area by the coefficient of variation method on the basis of in-depth understanding of geological environment characteristics.

## 2. Description of the Study Area

Lintong district lies in the northeast of Xi'an and covers an area of 915Km<sup>2</sup>. By the end of 2017, a total population of 710,000 people and 23 sub-districts were involved in study area. The geographical location of the study area is shown in figure1. From south to north, the landforms of study area are bedrock mountainous area, loess hilly, and loess tableland, diluvium plain and alluvial plain, respectively. Metamorphic rocks, quaternary loess, torrential and alluvium are the main rock-soil masses [8]. The main groundwater type is pore water and it decreases gradually from the north to the



south. There are more than ten faults in the region, of which the Linton-Chang'an fault is more active. The maximum annual rainfall of the study area was 954.9mm (2003), oppositely, the minimum annual rainfall was 302.3mm (1995) and the average annual rainfall was 587.7mm. With the development of social economy and the rich historical resources in Lintong district, careless development often results in the destruction of the ecological environment. For the unreasonable mining activities, the slope appearance has changed. As a result, there are many geological environment problems in study area.

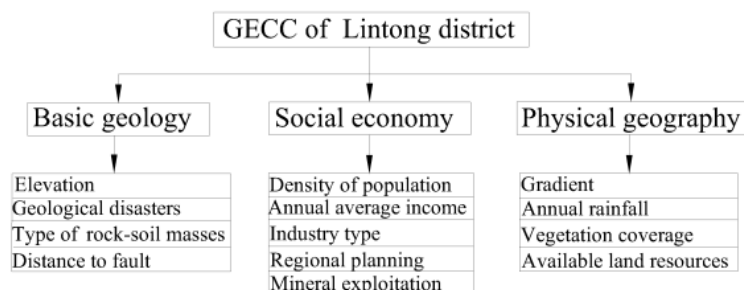


**Figure 1.** The geographical map of study area

### 3. Description of the Study Area

### 3.1. Evaluation Index System

Referring to administrative division and data collection, the paper takes sub-districts as the evaluation units. As there are no standards to select evaluation indexes [9], the paper takes previous studies and survey data as references. Based on the relationship between bearing carrier and bearing object, 13 evaluation indexes of GECC are finally determined, as shown in figure 2. Evaluation indicators include: altitude, geological hazards, type of rock-soil masses, distances to faults, population density, annual per capita income, industrial types, regional planning, mineral development, slope, annual rainfall, vegetation coverage and available land resources. In order to fully reflect the information contained in the original data and make it easy to calculate, paper takes the bigger and better type assign indexes attribute values. In conclusion, the classification of evaluation indexes is shown in table 1.



**Figure 2.** The evaluation index system of GECC

**Table 1.** The evaluation index categories of GECC

Name \ Grades	Excellent(5)	Good(4)	General (3)	Poor(2)	Very poor (1)
elevation(m)	≤500	(500,600]	(600, 700]	(700,800)	≥800
geological disasters	2	4	6	8	≥10
Type of rock-soil masses	Gravel	Sand	Loess	Silt soil	Silt
Distance to fault(Km)	≥12	(9, 12)	(6, 9]	(3, 6)	≤3
Density of population (people/Km <sup>2</sup> )	≤300	(300,600]	(600, 900]	(900,1200)	≥1200
Annual average income (1,000 dollar)	≤2	(2.0, 3.0]	(2.0, 2.5]	(2.5,3.0)	≥3.0
Industry type	Agriculture——4;Service industry——3.5;Industry——3				
Regional planning	≥6.0	(5.0, 6.0)	(4.0, 5.0]	(3.0, 4.0)	≤3.0
Mineral exploitation	Terrestrial heat——4;Construction material——3.5;Metals——3				
Gradient (°)	≤3	(3, 6)	[6, 9)	[9, 12)	≥12
Annual rainfall (mm)	≤500	(500,540]	(540, 580]	(580, 620)	≥620
Vegetation coverage (%)	≥30	(25, 30)	(20, 25]	(15, 20]	≤15
Available land resources (hectare)	≥1,400	(1,400, 1,000]	(1,000, 600]	(600, 200]	≤200

### 3.2. Dimensionless Treatment of Indicators

In order to reduce the impact on the calculation results, the evaluation indexes are treated dimensionless. The dimensionless calculation processes are as follow:

$$\text{Positive indicators: } Y_{ij} = \frac{X_{ij} - X_{i\min}}{X_{i\max} - X_{i\min}} \quad (1)$$

$$\text{Negative indicators: } Y_{ij} = \frac{X_{i\max} - X_{ij}}{X_{i\max} - X_{i\min}} \quad (2)$$

Where,  $Y_{ij}$  is the standardization of the  $i^{\text{th}}$  class and the  $j^{\text{th}}$  index.  $X_{ij}$  is the actual value of the  $i^{\text{th}}$  class and the  $j^{\text{th}}$  index.  $X_{i\max}$  is the maximum value of class  $i$  index;  $X_{i\min}$  is the minimum value of class  $i$  index.

### 3.3. Determination of Evaluation Index Weight

This paper uses the variation coefficient method to calculate the weight of each evaluation index. The variation coefficient method is an objective calculation method, which can avoid the influence caused by subjective factors. This method can use the information contained in each indexes to obtain the weights directly. The calculation process is as follows:

$$\text{Average: } \bar{X}_i = \frac{1}{n} \sum_{j=1}^n X_{ij} \quad (3)$$

$$\text{Standard deviation: } S_i = \sqrt{\frac{1}{n-1} \sum_{j=1}^n (X_{ij} - \bar{X}_i)^2} \quad (4)$$

$$\text{Variable coefficient: } Z_i = \frac{S_i}{\bar{X}_i} \quad (5)$$

$$\text{Weight: } w_i = \frac{Z_i}{\sum_{i=1}^n Z_i} \quad (6)$$

Where:  $i$  is the category of index;  $j$  is the specific indicator under each type of index.

### 3.4. The Selection of Evaluation Method

The evaluation methods of GECC mainly include ecological footprint method, state space method and comprehensive evaluation method. The advantages and disadvantages of each evaluation method are

shown in table 2. In this paper, a comprehensive evaluation model was established based on the comprehensive evaluation method. The comprehensive evaluation method is a method to evaluate multiple objects using multiple indexes, also known as the multi-variable comprehensive evaluation method, for example, to evaluate the social development level of different regions and the economic strength of different countries. The comprehensive evaluation model is an effective evaluation model with the advantages of comprehensive analysis, easy calculation and easy to understanding [10]. The comprehensive evaluation model established in this paper can be expressed by the following formula:

**Table 2.** The comparative table of evaluation method

Evaluation methods	Advantages	Disadvantages
Ecological footprint	Strong inter-regional contrast	Ignoring the impact of human activity
State space	The results are vivid and comprehensive	hard to build models
Comprehensive evaluation	Hierarchy is clear and comprehensive	Large data processing

Comprehensive evaluation method:

$$P = \sum_{i=1}^n Y_i \cdot W_i \quad (7)$$

Where, P is the GECC of the evaluation object.  $Y_i$  is the dimensionless value of the first evaluation index;  $W_i$  is the weight of the  $i^{th}$  evaluation index.

#### 4. Evaluation of Geological Environment Carrying Capacity

##### 4.1. Values of Geological Environment Carrying Capacity

The values of sub-districts were obtained by the method mentioned above. The calculation results are shown in table 3.

**Table 3.** The GECC values of sub-districts in study area

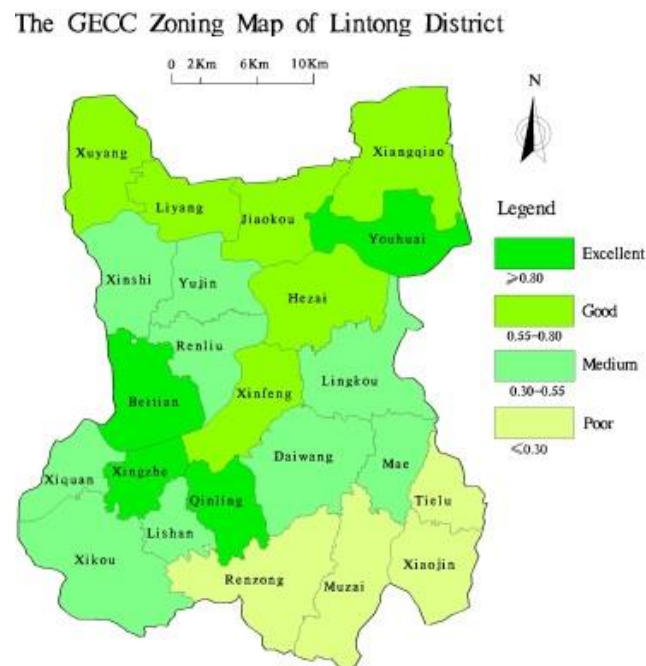
Sub-districts	Values	Sub-districts	Values	Sub-districts	Values	Sub-districts	Values
Xuyang	0.72	Liyang	0.75	Xiquan	0.50	Xingzhe	0.82
Jiaokou	0.69	Xiangqiao	0.62	Qinling	0.83	Daiwang	0.54
Xinshi	0.52	Yujin	0.49	Ma'e	0.48	Tielu	0.25
Hezai	0.68	Youhuai	0.83	Xiekou	0.51	Lishan	0.65
Beitian	0.87	Renliu	0.51	Renzong	0.28	Muzai	0.20
Xinfeng	0.66	Lingkou	0.52	Xiaojin	0.26		

##### 4.2. Classification Standards and Zoning Map of GECC

The values of geological environment carrying capacity were graded by trying standard deviation method, equal interval method, natural breakpoint method, and definition interval method. At last, equal interval method was adopted to divide it into four grades: excellent, good, medium and poor. The classification standard is shown in table 4. According to the classification standards in table 4, MapGIS6.7 was used to obtain the GECC zoning map of Lintong district, as shown in figure 3.

**Table 4.** The standard categories of GECC

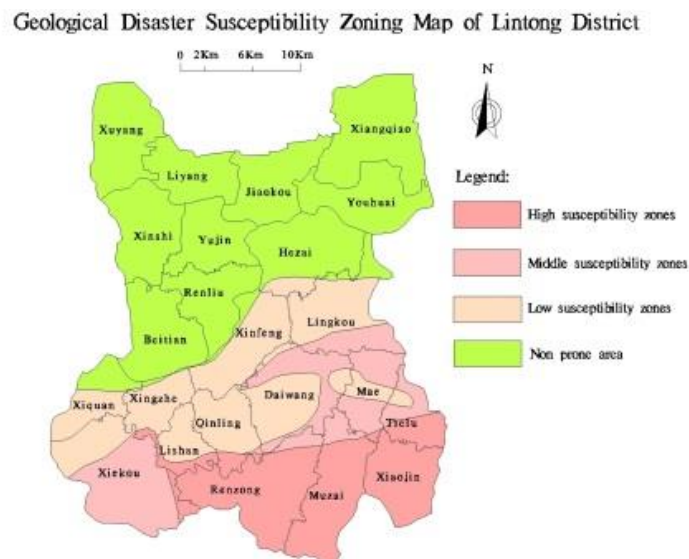
Grades	Excellent	Good	Medium	Poor
Intervals	$\geq 0.8$	(0.55, 0.8)	(0.3, 0.55]	$\leq 0.3$



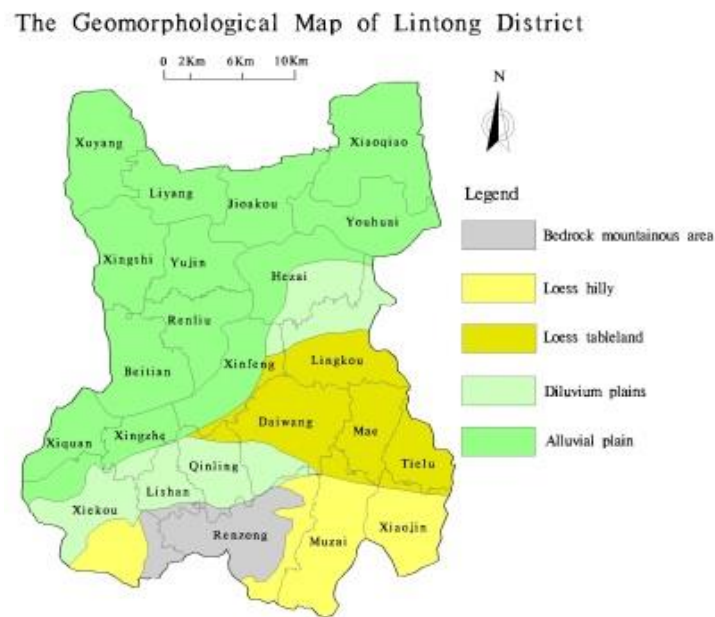
**Figure 3.** The GECC zoning map of Lintong district

#### 4.3 Test of Evaluation Results

Due to the particularity of GECC evaluation, there is no effective quantitative method to test the evaluation results. The paper tests the evaluation results from the qualitative aspect. Therefore, the geographical disaster vulnerability zoning map and geomorphology map were used to examine the evaluation results from a qualitative perspective. The geographical hazard vulnerability zoning map and geomorphological map of the study area are shown in fig. 4 and fig. 5.



**Figure 4.** Geological disaster susceptibility zoning map



As shown in figure 4, the bedrock mountainous area and loess hilly area in the south of the study area are medium and high risk areas of geological disasters, the diluvial plain and loess tableland in the central part of the study area are low risk areas of geological disasters, and the alluvial plain in the north of the study area is not prone to geological disasters. Combined with figure 3, it is easy to know that the GECC of the alluvial-diluvial plain is good, and the carrying capacity grade is excellent or good, loess tableland in the middle is medium, bedrock mountainous area and loess hilly region is poor. After testing, the evaluation results are consistent with the real situation and have *high accuracy*.

## 5. Conclusions

Based on the variation coefficient method, a comprehensive evaluation model with 13 evaluation indexes was established, which can accurately evaluate the GECC of the study area.

The GECC of study area was evaluated through the comprehensive evaluation model. The carrying capacity was divided into four categories: excellent, good, neutral, medium and poor by the equal interval method and the zoning map of GECC was obtained.

By the evaluation of GECC in study area, the accurate classification of carrying capacity grade was achieved and the results can provide references for the development planning of the research area.

## Acknowledgments

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## References

- [1] Carballo Penela, A., Sebastián Villasante, C., 2008. Applying physical input–output tables of energy to estimate the energy ecological footprint (EEF) of Galicia (NW Spain). *Energy Policy*, 36, 1148-1163.
- [2] Clancy, S.A., Worrall, F., Davies, R.J., Gluyas, J.G., 2018. An assessment of the footprint and carrying capacity of oil and gas well sites: The implications for limiting hydrocarbon reserves. *Science of the Total Environment*, 618, 586-594.
- [3] Jiang, X., Lu, W.-x., Zhao, H.-q., Yang, Q.-c., Chen, M., 2015. Quantitative evaluation of mining geo-environmental quality in Northeast China: comprehensive index method and support vector machine models. *Environmental Earth Sciences*, 73, 7945-7955.

- [4] Kirschbaum, M.U.F. et al., 2012. Comprehensive evaluation of the climate-change implications of shifting land use between forest and grassland: New Zealand as a case study. *Agriculture, Ecosystems & Environment*, 150, 123-138.
- [5] Lenzen, M., Murray, S.A., 2001. A modified ecological footprint method and its application to Australia. *Ecological Economics*, 37, 229-255.
- [6] Lynch, H.N., Greenberg, G.I., Pollock, M.C., Lewis, A.S., 2014. A comprehensive evaluation of inorganic arsenic in food and considerations for dietary intake analyses. *Science of the Total Environment*, 496, 299-313.
- [7] Peng, J., Du, Y., Liu, Y., Hu, X., 2016. How to assess urban development potential in mountain areas? An approach of ecological carrying capacity in the view of coupled human and natural systems. *Ecological Indicators*, 60, 1017-1030.
- [8] Pietrapertosa, F., Cosmi, C., Macchiato, M., Salvia, M., Cuomo, V., 2009. Life Cycle Assessment, ExternE and Comprehensive Analysis for an integrated evaluation of the environmental impact of anthropogenic activities. *Renewable and Sustainable Energy Reviews*, 13, 1039-1048.
- [9] Wackernagel, M., Monfreda, C., Erb, K.-H., Haberl, H., Schulz, N.B., 2004. Ecological footprint time series of Austria, the Philippines, and South Korea for 1961–1999: comparing the conventional approach to an ‘actual land area’ approach. *Land Use Policy*, 21, 261-269.
- [10] Wang, Z., Wang, Y., Wang, L., Zhang, T., Tang, Z., 2017. Research on the comprehensive evaluation system of eco-geological environmental carrying capacity based on the analytic hierarchy process. *Cluster Computing*.