RETRACTED ARTICLE: Evaluation of human activity intensity in geological environment problems of Ji’nan City

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Abstract

Human activity intensity evaluation is the basis of analyzing the impact of human activity on the region. With increasing scale and quantity of human activity, the impact on the ecological environment is also more and more serious. The multifactor evaluation model of human activity intensity is established by determining the classification standard index. Firstly, population density, gross domestic product (GDP) per capita, mining points, construction land ratio and land utilization ratio are selected as quantitative indexes. Secondly, the weights of evaluation indexes are obtained by using objective valuation method. Further work, the quantitative evaluation model and systematic analysis of human activity intensity for Ji’nan city are established by multifactor method. The results show that the areas with the highest intensity of human activities are mainly distributed in Ji’nan urban area, the areas with higher intensity are mainly distributed in some towns of Licheng District and the urban areas of counties and cities, the areas with middle intensity are mainly distributed in the areas near Ji’nan urban area and counties, and the areas with lower intensity are mainly distributed in some areas far away from counties and cities. Quantitative evaluation of human activity intensity is helpful to investigate the changes of ecological environment.

Introduction

Human activity intensity is a composite indicator for representing the influences of human activity on land surface (Xu et al., 2016). The human activity intensity is the main cause of geological environment problems (Zang et al., 2019). With the population growth and social progress, the scale and quantity of human activity are getting larger and larger, and the influence on geological environment is becoming more serious (Li, 2011). As the factors of geological environment, human activity keeps pace with natural process, and even surpasses the role of natural process in some aspects, so it is necessary to carry out special research on the evaluation of human activity intensity, and make further analysis on the relationship between human activity intensity and geological environment at the same time (Wang et al., 2009).

The sharp increase of human activity intensity changes the local topography and geomorphology, leading to geological environment deterioration (Shen et al., 2018). Human activity has a major impact on the geological environment, in addition to, is also related to the geological environment carrying capacity (Zou, 2012). Geological environment carrying capacity is one of the criteria for judging the compatibility of human activity and geological environment. The evaluation of geological environment carrying capacity and human activity intensity is the key to achieving sustainable development of regional economy (Li & Wang, 2019). The interference of human activity intensity and the changes in the geological environment system have a complicated relationship, and often nonlinear (Verstraeten et al., 2017). When the human activity intensity exceeds the carrying capacity, the geological environment will lose its security. The impact of human activity on the surrounding environment needs to be quantified (Yang et al., 2019). A multi-index superposition system was established based on weights to evaluate the human activity intensity (Liu et al., 2018). Trend analysis and residual analysis were used to calculate the human activity intensity based on MODIS-NDVI data, combining with remote sensing data and regional socioeconomic data (Wen & Yao, 2018). The human activity intensity at the regional scale can be monitored by remote sensing techniques (Gao et al., 2019). Although there are many methods for assessing human activity intensity from the geological environment, there is no uniform system or index for the quantitative model. In view of this, this paper establishes a model to quantitatively analyze the evaluation of human activity intensity in geological environment. Quantitative evaluation is the value judgment of the quantitative results for the evaluation objects by using mathematical methods with collecting and processing data.

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As the capital of Shandong Province, Ji’nan City has a dense population and complex geological environment. The evaluation of human activity intensity is particularly difficult in geological environmental problems. The establishment of index system is the key of regional human activity intensity evaluation. The evaluation of human activity intensity involves three aspects of society, economy and culture, and each aspect is affected by many factors. If various factors are collected, a large indicator system will be obtained, which will increase the workload. Based on the development characteristics of Jinan city and the correlation with environmental engineering geological problems, population density, GDP per capita, mining points, construction land ratio and land utilization ratio are selected as quantitative indexes. The weights of indexes are obtained by using objective valuation method. Further work, the quantitative evaluation model and systematic analysis of human activity intensity for Ji’nan city are established by multifactor method.

Materials and methods

Evaluation index

Due to the difference in dimensions and units between the five indexes of population density, per capita GDP, mining points, construction land ratio and land utilization ratio, it is impossible to directly carry out analysis and comparison. Therefore, in order to unify the indexes, these five indexes should be treated nondimensionally by adopting the normalized dimensionless method. After normalized calculation, the values of each index data are 0 and 1. The normalized dimensionless formula can be described as:

$$y_{ij} = \frac{x_{ij} - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \quad (i = 1, 2, 3 \ldots n; \ j = 1, 2, 3 \ldots m)$$  

where $x_{ij}$ is the $j$-th original data of the $i$-th index, $n$ is the number of original data of the $i$-th index, and $m$ is the number of indexes; $x_{\text{max}}$ and $x_{\text{min}}$ are the maximum and minimum values of the $i$-th index, respectively.

After dimensionless, all indexes are converted to specific values between 0 and 1, which can be compared and analyzed.

Index weights

Subjective weighting method and objective weighting method are commonly used to determine the index weights. Subjective weighting method refers to the
method that researchers determine index weight by subjective judgment based on their own professional knowledge and experience. The idea of subjective weighting method is by inviting a group of experts who have a deep understanding of the research problem, and let them assign weight to each evaluation indexes independently. Then, the expert opinions are gathered, and the average and variance of each indexes weight are calculated. The subjective weighting method often depends on the experience of researchers and their familiarity with the research area, which is prone to bias. According to the relationship between the original data, the objective weighting method uses mathematical model to determine the weight. Objective weighting method relies on sufficient sample data, which can effectively avoid the influence of researchers’ subjective factors on the results, so the objective weighting method is used for quantitative analysis in this paper.

The coefficient of variation method is one of the objective weighting methods, which determines the weight of indexes according to the degree of difference between the values of each index. The coefficient of variation method is used to objectively assign values to each index, and the steps for determining the weight by the coefficient of variation method are as follows:

Determination of coefficient of variation $V_i$ can be described as:

$$V_i = \frac{\delta}{x_i} \quad (i = 1, 2, 3 \ldots n)$$  \hspace{1cm} (2)

where $\delta$ is the standard deviation of each values of the $i$-th index, and $x_i$ is the average of each values of the $i$-th index.

The weight $\omega_i$ for each indexes can be obtained by simplifying the coefficient of variation, which is shown as follows:

$$\omega_i = \frac{V_i}{\sum_{i=1}^{n} V_i} \quad (i = 1, 2, 3 \ldots n)$$  \hspace{1cm} (3)

The weights of each indexes for the quantitative evaluation of human activity intensity are obtained
accord the above steps, and the results are shown in Table 1.

**Calculation of human activity intensity**

According to the above data results, the index \( F_j \) representing the human activity intensity is calculated by weighting method, the mathematical model can be described as:

\[
F_j = \sum_{i=1}^{n} \omega_i y_{ij} \quad (i = 1, 2, 3 \ldots n; \ j = 1, 2, 3 \ldots m)
\]

(4)

where \( F_j \) is the intensity index of human activity, \( \omega_i \) is the weight for each indexes, \( y_{ij} \) is normalized dimensionless value.

After calculation, the index of human activity intensity under the jurisdiction of Ji’nan city is shown in Table 2.

**Results**

According to quantitative evaluation model, the index of human activity intensity in Ji’nan area is obtained, and all township-level street offices in Ji’nan are divided into four levels, highest, higher, middle, lower, according to the values of 0.6, 0.4–0.6, 0.2–0.4, and 0.2, respectively. The research area is divided into many grids, and all partitioned grids are attached the index of human activity intensity, as shown in Figure 1. After the vectorization in the comprehensive partition map, the comprehensive partition of different grades of human activity intensity is shown in Figure 2.

As can be seen from Figure 2, the areas with the highest intensity of human activity are mainly distributed in the urban areas of Lixia District, Zhongcheng District, Huaiyin District, Tianqiao District and Licheng District. The higher areas are mainly distributed in some villages and towns of Licheng District, Zhangqiu District and Bucun Sub-district Office, Changqing District, Jiyang County District, Shanghe County and Pingyin County. The middle areas are mainly distributed in the areas close to urban areas of Ji’nan City and each counties. The lower areas are mainly distributed in the areas far away from the county towns of Shanghe County and Pingyin County and in a few areas of Changqing District and Zhangqiu.
District. The highest index is Lixia District of Jinan City, with a value of 0.87. The lowest index is Cuizhai Town in Jiyang County and Yuhuangmiao Town in Shanghe County, only with a value of 0.11. The results are in good agreement with the current economic and social development in various places, and also reflect the great difference of human activity intensity.

Discussion and conclusions

The areas with highest intensity of human activities are mainly distributed in the urban areas of Lixia District, Zhongcheng District, Huaiyin District, Tianqiao district and Licheng District. The higher areas are mainly distributed in some villages and towns of Licheng District, Zhangqiu District, Bucun Sub-district Office, Changqing District, Jiyang County, Shanghe County and Pingyin County. The middle areas are mainly distributed in the areas close to Jinan City and the districts and counties. The lower areas are mainly distributed in the areas far away from the county seat of Shanghe County and Pingyin County and in a few areas of Changqing District and Zhangqiu District. The results are in good agreement with the current economic and social development in various places.

Disclosure statement

No potential conflict of interest was reported by the authors.

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