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Research Article

Optimized Neural Network for Research Evaluation of Mineral Resources Carrying Capacity in Southern Shaanxi

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Evaluation of the carrying capacity of mineral resources is one of the important research content in the implementation of sustainable development. Based on analyzing the metallogenic geological characteristics, distribution, and resource status of mineral resources in southern Shaanxi, this paper establishes an analysis model of mineral resources and mineral advantages based on the analytic hierarchy process and applies them to evaluate the advantages of mineral resources. To provide optimal and efficient results, an improved model of an artificial neural network based on the bat optimization algorithm has been utilized. Through model analysis, the potential value and carrying capacity of mineral resources in three major prefecture-level cities in southern Shaanxi are comprehensively evaluated and analyzed. The results show that the main dominant minerals in southern Shaanxi are gold, lead zinc, and molybdenum ore. There are three grades of mineral resources carrying capacity: Shangluo City is an excellent grade, Hanzhong City is a good grade, and Ankang City is a general grade.

1. Introduction

Mineral resources are a kind of important material basis for human survival and social development and important pillars of the national economy. The sustainable utilization of mineral resources plays a vital role in the sustainable development strategy and high-quality development of the entire national economy. The mineral resources carrying capacity refers to the carrying capacity of the economically recoverable reserves of mineral resources (or their production capacity) for social and economic development under the prevailing scientific and technological natural environment and social and economic conditions in a foreseeable period. It is an important indicator to measure the sustainable guarantee supply of mineral resources in a country or region and the degree to which it meets the needs of social and economic development and can also embody and reflect the guarantee and carrying capacity of its regional mineral resources to a certain extent.

Southern Shaanxi is rich in mineral resources, characterized by wide distribution, variety, and obvious regional characteristics. It is a key area of mineral resources in Shaanxi Province and even the whole country. Southern Shaanxi is dominated by nonferrous metals, precious metals, ferrous metals, and various nonmetallic minerals. Regional economic development also mainly comes from the development and utilization of mineral resources. The rational development and utilization of mineral resources is an important foundation for the sustainable development of the regional economy in southern Shaanxi. Due to environmental protection and other reasons, some mining enterprises have stopped production, and the mining economy has experienced a serious decline, affecting regional economic development to a certain extent. The contradiction between the rapid economic and social development in southern Shaanxi and the fragile mineral resources carrying capacity and the contradiction between the extensive growth mode and the shortage of resources are increasingly prominent, and it is urgent to carry out research and evaluation work on the mineral resources carrying capacity [1]. Based on the current situation of resources in southern Shaanxi, this paper puts forward a set of scientific mineral resources carrying capacity evaluation system and proposal in order to improve the guarantee capacity of mineral resources and scientifically and rationally develop and utilize mineral resources, which will be of extremely great significance to promote the high-quality development of mining economy in southern Shaanxi [2, 3]. To provide optimal and efficient results, an improved model of an artificial neural network based on the bat optimization algorithm has been utilized. The paper has been organized as follows: in Section 2, an overview of the mineral resources is explained in southern Shaanxi. Section 3 describes the analysis of advantageous minerals for mineral resources in southern Shaanxi. In section 4, the artificial neural network and its optimization by the bat algorithm have been explained. Section 5 represents a comprehensive analysis of the potential value and carrying capacity of mineral resources in southern Shaanxi. Finally, the paper has been concluded in Section 6.

2. Overview of Mineral Resources in Southern Shaanxi

2.1. Overview. Shaanxi Province is located in the inland area, with a land area of about 205,600 square kilometers, about 870 kilometers long from north to south, and 200 to 500 kilometers wide from east to west. The region is long and narrow, with the topographical feature of the north-south high and the middle-low. The mountainous area such as plateaus, mountains, and valleys accounts for about 81% of the total area. From north to south, the area under the jurisdiction is the Loess Plateau in northern Shaanxi, the Weihe Plain in Guanzhong, and the Qinba Mountains in southern Shaanxi. The Qinba Mountains in southern Shaanxi include the Qinling Mountains, Bashan Mountains, and Hanjiang Valley, which constitute a diverse topography of alpine canyons and alluvial plains. The Hanjiang River flows between the Qinling Mountains in the north and the Bashan Mountains in the south, forming a unique topographical feature of "two mountains sandwiching one river." The Qinling Mountains are about 400–500 kilometers long from east to west and about 300 kilometers wide from north to south in the province. Among them, the altitudes of Zhongnan Mountain, Taibai Mountain, and Huashan Mountain are 2,604 meters, 3,767 meters, and 2,160 meters, respectively; Bashan Mountains are located in the southernmost, with an altitude of 1,500–2,000 meters. The mountainous area of the region accounts for 82.25% of the total area of southern Shaanxi.

Southern Shaanxi is located in the southern part of Shaanxi Province, referring to the area south of the Qinling Mountains, mainly including Hanzhong, Ankang, and Shangluo cities, adjacent to Henan and Hubei in the east; Gansu in the west; Sichuan, Chongqing, and Hubei in the south; and connected to three cities of Baoji, Xi'an, and Weinan in Guanzhong in the north of Shaanxi Province. In 2020, the total population in the administrative region of southern Shaanxi is about 7.75 million, accounting for 19.60% of the total population of Shaanxi Province, and the land area is about 70,000 square kilometers, accounting for 34% of the total land area of Shaanxi Province. The development and utilization of minerals have promoted industrial development and consolidated the regional economic foundation. According to statistics, in 2017, the gross industrial output value of industrial enterprises above the designated size in Shaanxi Province was RMB 2.485443 trillion, an increase of 18.8% over the previous year. The mining and related processing and manufacturing industries completed RMB 1.419827 trillion, accounting for 57.1% of the province's gross industrial output value above the designated size (according to the Shaanxi Provincial Department of Land and Resources, 2018), of which southern Shaanxi is the main contributor to Shaanxi's mining economy.

Southern Shaanxi is located in the Qinling Mountains metallogenic belt, with complex geological structure and rich mineral resources [4]. It is an important metallogenic belt in my country; 83 kinds of minerals have been discovered, mainly nonferrous metals, precious metals, ferrous metals, and nonmetallic minerals [5]. Among the 2,044 mineral deposits in the province, 1,071 are located in southern Shaanxi [6–8], accounting for 52.40% of the total number of mineral deposits in the province. Among them, Shangluo City has the largest number of deposits (425), followed by Hanzhong City (344) [6] and Ankang City (302) [7]. It is the most important polymetallic mineral resource enrichment area among the proven resources in the province. It has laid a solid resource foundation for the economic development of southern Shaanxi. Due to the differences in metallogenic geological background and geological conditions, there are obvious differences in the types and quantities of main minerals in different regions. It can be seen from Table 1 that gold, iron, manganese, copper, nickel, lead, zinc, phosphorus, sulfur, serpentine, and other minerals are mainly distributed in the Hanzhong area; gold, iron, antimony, mercury, tungsten, titanium, vanadium, barite, lead, zinc, and other minerals are mainly distributed in Ankang area; and iron, molybdenum, silver, antimony, copper, potassium feldspar, vanadium, titanium, lead-zinc, crystal, and other minerals are mainly distributed in Shangluo area. In recent years, the reserves of gold, copper, lead, zinc, iron, molybdenum, antimony, manganese, and other important minerals in southern Shaanxi have been declining year by year, showing negative growth, and resource crisis mines have continued to emerge. The contradiction between the situation of mineral resources and the need for economic and social development is becoming increasingly prominent.

Figure 1 shows the distribution figure of major mineral resources in southern Shaanxi.

Table 2 indicates the list of weights of second-level indicators.

2.2. Analysis of Metallogenic Characteristics. Southern Shaanxi is located in the Qinling Mountains and the Daba Mountains. It is a very important polymetallic metallogenic belt in my country, and the mine resources are very rich. The three cities in southern Shaanxi span the Xiaoqinling Mountains, North Qinling Mountains, South Qinling

Table 1: Distribution table of main mineral resources in southern Shaanxi.

Serial number	Area	Mainly distributed minerals
1	Hanzhong	Gold, iron, manganese, copper, nickel, lead, zinc, phosphorus, sulfur, serpentine, etc.
2	Ankang	Gold, iron, antimony, mercury, tungsten, titanium, vanadium, barite, lead-zinc, etc.
3	Shangluo	Iron, molybdenum, silver, antimony, copper, potassium feldspar, vanadium, titanium, lead-zinc, crystal, etc.

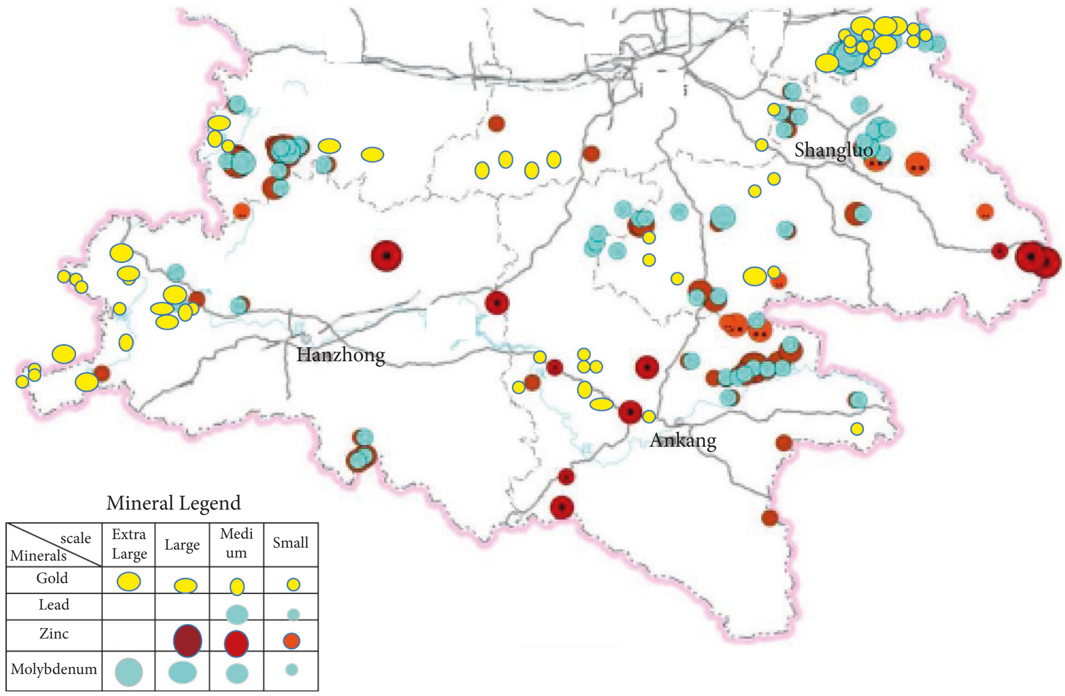

Figure 1: Distribution figure of major mineral resources in southern Shaanxi.

Table 2: List of weights of second-level indicators.

Serial number	Second-level indicator B	Weight
1	Mineral resources themselves B1	0.1796
2	Mineral resources survey and exploration B2	0.2496
3	Development and utilization of mineral resources B3	0.2364
4	Socioeconomic benefits B4	0.3343

Mountains, Motianling, and the edge of the Yangtze platform [9–11]. They have excellent metallogenic geological conditions and are rich in nonferrous metals, precious metals, ferrous metals, and various nonmetallic minerals [12–14]. The distribution of mineral resources in the three cities in southern Shaanxi is slightly different: Hanzhong is rich in iron, manganese, titanium, nickel, metallurgical quartz stone, solvent limestone, and other minerals; Ankang is rich in mercury, pyrite, barite, and other minerals resources; and Shangluo is rich in iron, titanium, lead, zinc, gold, and other mineral resources. Figure 2 shows the hierarchical structure model of comprehensive evaluation of advantageous mineral resources in southern Shaanxi.

2.2.1. Gold Ore. As the dominant mineral in the Qinling Mountains metallogenic belt, the output of gold ore is mainly controlled by the tectonic-magmatic belt. There are two regional gold metallogenic belts in the north and south. The gold ores in the belt follow the distribution of regional large faults and own the characteristics of close magmatism in the Indo-Chinese-Yanshan period. The dominant types of gold ores are mainly structural altered rock type and quartz vein type, which are concentrated in the West Qinling Mountains and Xiaoqinling Mountains areas.

The gold ores in Shaanxi Province are mainly distributed in the areas under the jurisdiction of cities such as Xi'an, Baoji, Weinan, Hanzhong, Ankang, and Shangluo. Among them, the areas under the jurisdiction of Hanzhong City and Shangluo City have a relatively large number of mineral fields, accounting for 21.28% and 31.38% of the total gold mining fields in the province, respectively, while the reserves of gold mineral resources are mainly concentrated in the areas under the jurisdiction of Baoji City and Shangluo City, accounting for 23.77% and 32.86% of the province's total identified gold reserves, respectively.

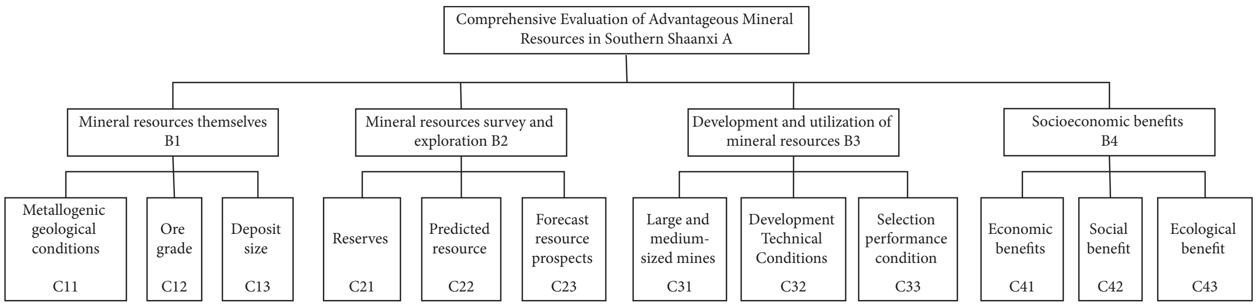

FIGURE 2: The hierarchical structure model of comprehensive evaluation of advantageous mineral resources in southern Shaanxi.

2.2.2. Lead-Zinc Ore. The large-scale mineralization of lead-zinc ore in the West Qinling Mountains area generally includes two stages: Devonian tectonic rifting-contemporaneous depositional mineralization and Triassic tectonic-magmatic superimposed mineralization.

The geographical location of lead-zinc ore in Shaanxi Province is mainly distributed in the areas under the jurisdiction of Baoji, Ankang City, and Shangluo City in southern Shaanxi. Lead-zinc resource reserves account for 86.93% of the province's total lead-zinc resource reserves. Among them, Baoji City's lead and zinc resource reserves account for 26.44% and 51.58% of the province's total lead and zinc resource reserves, respectively, Shangluo City's lead resource reserves account for 47.74% of the province's total lead resource reserves, and Ankang City's zinc resource reserves account for 23.58% of the province's total zinc resource reserves. The area of Fengxian-Taibaimiao in Baoji City, Shanyang-Zhashui and Zhen'an in Shangluo City, and the northern part of Xunyang in Ankang City are relatively concentrated areas of lead-zinc ore in Shaanxi Province.

2.2.3. Iron Ore. Iron ores are distributed in all prefecture-level cities in Shaanxi Province. However, iron ores with industrial significance are mainly distributed in the areas under the jurisdiction of Hanzhong City, Ankang City, and Shangluo City in southern Shaanxi [15]. Its mineral deposits account for 74.83% of the province's total iron deposits, and its iron ore resource reserves account for 96.55% of the province's total iron ore resource reserves. Among them, the Mian-Lue-Yang area in Hanzhong City and the Bijigou area in Yangxian County, the Ziyang-Zhenping area in Ankang City, and the Zhashui-Shanyang area in Shangluo City are areas with relatively more iron deposits. The iron resources reserves are mainly distributed into three types of deposits: magmatic segregation type, bed-controlled hydrothermal type, and volcanic-sedimentary metamorphic type.

2.2.4. Copper Ore. Copper ores are distributed in 6 prefecture-level cities in the southern Shaanxi and Guanzhong regions. Shangluo City has the largest number of copper mines, accounting for 52.17% of the province's total copper mines and 28.86% of the province's total copper resource reserves, followed by Hanzhong, accounting for 20.87% of the province's total copper mines, accounting for 20.82% of the province's total copper resource reserves. Weinan City has a small number of ore deposits, but its copper resource reserves account for 25.03% of the province's total copper resource reserves. The Mian-Lue-Yang area of Hanzhong City, the Zhashui-Shanyang area of Shangluo City, and the Shangzhou-Danfeng area are the areas with relatively more copper deposits. The identified resources and reserves of copper deposits are mainly distributed in two types of deposits: porphyry type and tectonic hydrothermal type.

2.2.5. Molybdenum-Tungsten Ore. Molybdenum and tungsten ores are distributed in the northern margin of the Qinling Mountains metallogenic belt, and the main type is porphyry. In recent years, large-scale molybdenum deposits have been discovered in the West Qinling Mountains, and breakthroughs have been made in the prospecting of molybdenum ore. Wenquan, Jiangligou, and other porphyry molybdenum-tungsten (copper) ores and a series of prospecting clues have been discovered and several molybdenum deposits (points) such as Yueheping, Xigou and Guilin'gou in the Zhen'an-Ning-Shaan junction area of the South Qinling Mountains. Recently, good molybdenum mineralization has been discovered in the gold deposits of the Xiaoqinling Mountains gold ore concentration area, and the molybdenum resources of individual deposits can reach a medium scale. In the west of the molybdenum deposits in Jinduicheng, the molybdenum (lead) deposits accompanying silver and lead in Xigou, Huaxian County, have been discovered in the latest exploration, which further shows that the Qinling metallogenic belt has huge potential for molybdenum prospecting.

2.2.6. Antimony Ore. Mercury ore and antimony ore are mostly symbiotic, mainly in the epithermal medium-low temperature hydrothermal type. The distribution of deposits is controlled by stratigraphy and structure, and they are mainly distributed in the southern South Qinling Mountains. The Triassic rift basin that traverses the east and west of the Qinling Mountains metallogenic belt is an important mercury-antimony-gold polymetallic metallogenic belt in Qinling Mountains, in which the argillaceous fine clastic turbidite sedimentary rock series is an important ore-hosting rock series [16–18]. At present, dozens of large and medium-sized mercury-antimony deposits such as Yawan, Ganzhai, Gongguan, and Qingtonggou and numerous mineral fields have been discovered, which constitute a veritable "golden belt" of the Qinling Mountains, and the prospecting practice in recent years has proved that its prospecting potential is huge.

3. Analysis of Advantageous Minerals of Mineral Resources in Southern Shaanxi

Southern Shaanxi is rich in mineral resources and has many kinds of minerals. This paper selects advantageous minerals and strategic minerals for follow-up evaluation. This paper collects and sorts out the information of related projects such as the utilization status of mineral resources in southern Shaanxi and the evaluation of the potential of mineral resources in Shaanxi Province and finally selects four advantageous minerals in southern Shaanxi, gold, lead, zinc, and molybdenum, for analysis.

This paper adopts an optimized version of an artificial neural network for this process. The optimized neural network is a network with optimal weights selection. In the following, the structure of the optimized neural network has been described. Table 3 shows the analysis list of the advantages of four main mineral resources in southern Shaanxi.

4. Optimized Neural Network Based on Bat Optimization Algorithm

Optimization is a topic in mathematics, computer science, and operations research in which the best element (according to a set of criteria) is selected from a set of options. Optimization has significant applications in "artificial intelligence". Artificial neural networks (ANNs) are computational systems that are inspired by but not necessarily related to biological neural networks. Today, a variety of neural network algorithms are widely used to solve "machine learning" problems [19]. Indeed, the use of neural networks in various issues is of interest to researchers.

Today, perceptron neural networks are still of particular importance and are a fast and reliable solution to classification problems. In many complex mathematical problems that lead to the solution of complex nonlinear equations, a multilayer perceptron network can be used simply by defining appropriate weights and functions [20].

In this type of network, an input layer is used to apply the problem inputs to a hidden layer and an output layer ultimately provides the solutions to the problem. The model used in the simulation (input X_i is multiplied by its weight and enters the second layer (hidden layer) and then the sum of the coefficients of all X_i is calculated and a certain value is obtained) and again enters the layer as input. It is then, and this process continues until it reaches the output layer, and in the output layer, the output function is obtained by applying the output function to it.

4.1. Multilayer Perceptron Neural Networks. An artificial neural network (ANN) is an idea for information processing that is inspired by the biological neural system and processes information like the brain. The key element of this idea is the new structure of the information processing system. This system is made up of a large number of highly interconnected processing elements called neurons that work together to solve a problem. In traditional computational methods, a series of logical expressions are used to operate. In contrast, neural networks use a set of nodes (as neurons) and edges (as synapses) to process data. In this system, inputs flow into the network and a series of outputs are generated.

A popular method to better minimize the error between the network output and the experimental data is to utilize the backpropagation (BP) approach. Based on the BP method, the idea is to the optimal selection of the weights of the neurons to minimize this error and to provide an efficient confirmation with the experimental data. Error minimization of the BP method is based on the gradient descent (GD) algorithm. A drawback of the GD method is that sometimes stuck in the local minimum point affects the network's success.

The network output for nodes can be achieved based on two stages. First, the input-weighted summation in the input has been obtained as follows:

$$z_i = \sum_{j=1}^{n} w_{ij}\alpha_i + \beta_j, \tag{1}$$

where α_i specifies the input data, β_j signifies the bias of neuron number j, and w_{ij} describes the connected neurons between α_i and the j^{th} hidden neuron.

The activation function is used to activate the neuron output. There are several activation functions for MLP networks. This study uses the sigmoid function for this purpose. The sigmoid function is achieved based on the following equation:

$$f_j(x) = \frac{1}{1 + e^{-y_j}}, \tag{2}$$

where f_j is the activation function and y is the network output.

At last, the network output is achieved as follows:

$$y_i = \sum_{j=1}^{m} w_{kj}\alpha_i + \beta_k. \tag{3}$$

4.2. Bat Optimization Algorithm. Today, there is a great tendency to use algorithms inspired by nature and based on the swarm intelligence of animals. Especially in the category of optimization techniques, these algorithms have been very popular [21]. With a close look at the nature and the great variety of animals that collectively follow certain methods in their lives, it is obvious that many algorithms can be inspired by them. For example, the genetic algorithm was first introduced by John Holland. This algorithm uses Darwin's principles of natural selection to find the optimal formula for predicting or matching the pattern.

Also, the particle swarm algorithm is based on the swarm behavior of birds and was proposed in 1975 by Kennedy and Eberhart. There are many algorithms in this field such as the

Table 3: Analysis list of the advantages of four main mineral resources in southern Shaanxi.

Indicators and weight minerals	B1 0.1796			B2 0.2496			B3 0.2364			B4 0.3343			Comprehensive weight	Ranking
	C11 0.2978	C12 0.4925	C13 0.2096	C21 0.4425	C22 0.2787	C23 0.2787	C31 0.2385	C32 0.2943	C33 0.4672	C41 0.4513	C42 0.2184	C43 0.3304		
Gold ore	0.2899	0.2010	0.1899	0.3211	0.2522	0.2011	0.2310	0.2115	0.2610	0.3511	0.2410	0.2360	0.2489	2
Zinc ore	0.3989	0.4652	0.3656	0.4262	0.3856	0.3406	0.3232	0.3108	0.4121	0.4477	0.3862	0.4772	0.3949	1
Lead ore	0.2010	0.2502	0.1501	0.3211	0.1542	0.1262	0.1846	0.2577	0.2017	0.2974	0.2120	0.2501	0.2171	3
Molybdenum ore	0.1704	0.1356	0.1420	0.1761	0.1523	0.1785	0.1902	0.1403	0.1725	0.0985	0.0510	0.0621	0.1391	4

world cup optimization algorithm, cuckoo algorithm, and firefly algorithm. It should be noted that one of the most important discoveries of modern science that is the focus of many scholars and scientists today and has led to the solution of many unsolved problems is the subject of artificial neural networks that are inspired by human neural nature. Based on the cases and examples mentioned, we conclude that it is being added to nature-inspired algorithms day by day.

The bat algorithm is a metaheuristic algorithm inspired by the swarm behavior of bats in the wild, introduced in 2010 by Yang. This algorithm is based on the use of sound reflection by bats. Bats find the exact path and location of their prey by sending sound waves and receiving reflections. When the sound waves return to the transmitter (bat), the bird can draw an acoustic image of the obstacles in front of its surroundings and see the surroundings well even in complete darkness. Using this system, bats can detect moving objects such as insects and immobile objects such as trees. The bat algorithm is based on the echo detection feature of microbats. In general, there are two types of bats, the first type is large bats, and the second type is called small bats. Microbats use this feature for night flying and hunting. Echo detection of microbats is in practice a perceptual system in which ultrasonic waves are generated to obtain echoes. The bat's brain and nervous system can create an image of its surroundings and details by comparing transmitted and reflected waves.

This ability allows microbats to detect their prey in complete darkness. The intensity of the wave produced by the bat is 130 decibels, and it uses the frequency of 15 kHz to 200 kHz for hunting prey. This is while the human hearing range is from 20 Hz to 20 kHz. In order to identify the data, the bat must be able to separate the sound produced by it from its echo. Microbats have two methods for this purpose. Echo detection with short time cycles: these bats can detect the sound sent by themselves from the reflected sound with the help of timing. Echo detection with long time cycles: these bats produce a continuous sound and separate the pulses and echoes by changing the frequency. They can change the pulse of any output frequency depending on the flight speed. In this way, the received echo is still in the appropriate hearing range.

The following three ideal rules are used to develop this algorithm:

(i) Using bounce detection, all bats can estimate the distance and distinguish between prey and fixed obstacles.

(ii) Bats are randomly searching for prey at speed v_i in position x_i with constant frequency f_{min} with variable wavelength λ and loudness A_0. They can automatically adjust the wavelength of their emitted pulses and adjust their pulse emission rate, $r \in (0,1)$, according to the proximity of their prey.

(iii) Although the volume can be changed in different ways, it is assumed that the volume changes from a large (positive) value of A_0 to a constant minimum value, A_{min}.

(iv) We can also use this approximation, which is generally the frequency f in a range $[f_{\min}, f_{Max}]$, which corresponds to a wavelength spectrum as $[\lambda_{\min}, \lambda_{Max}]$.

Each bat depends on the speed v_i^t and the location x_i^t by repeating t in the next d-dimensional search or the solution space.

Among all bats, there is only one optimal solution, x^*, so the three rules mentioned in the previous section can be calculated using the following formulas:

$$\begin{aligned} F_i &= f_{\min} + (f_{Max} - f_{\min}) \times \beta, \\ V_i^t &= v_i^{t-1} + \left(x_i^{t-1} - x^*\right) f_i, \\ X_i^t &= x_i^{t-1} + v_i^t, \end{aligned} \tag{4}$$

where β describes a random value between 0 and 1 which is generated by a uniform random distribution.

As mentioned, wavelength or frequency can also be used for implementation. Here, $f_{\min} = 0$ and $f_{\mathrm{Max}} = 1$, which is interesting depending on the size of the problem. Each bat is first assigned a random frequency obtained uniformly from $[f_{\min}, f_{\mathrm{Max}}]$. For this reason, it can be said that the bat algorithm is a frequency scale algorithm so that it provides a balanced combination of exploration and exploitation. Pulse amplitude and rate provide an automatic mechanism for automatic control and magnification of the area leading to prescribed solutions. With these consumptions, we have the following:

$$\begin{aligned} A_i^{t+1} &= \alpha A_i^t, \\ r_i^{t+1} &= r_i^0 \times [-\exp(-\gamma t)], \end{aligned} \tag{5}$$

where α and γ represent two constant variables.

The function α is similar to the function of the temperature reduction factor in the simulated annealing algorithm. For $0 < \alpha < 1$, $\gamma > 0$, when $t \longrightarrow \infty$,

$$A_i^{t+1} \longrightarrow 0 r_i^{t+1} \longrightarrow r_i^0. \tag{6}$$

In the simplest case, $\gamma = \alpha$ can be considered. The simulations performed in this algorithm are considered: $\gamma = \alpha = 0.98$.

In this study, the bat optimization algorithm has been used to minimize mean square error (MSE) between y_i and z_i.

The equation of the MSE is formulated as follows:

$$\mathrm{MSE} = \frac{1}{n} \sum_{j=1}^{n} \sum_{i=1}^{m} \left(y_i(k) - z_i(k)\right)^2. \tag{7}$$

Therefore, the pseudo-code of the present study can be considered as follows:

(1) Initializing the bat algorithm

(2) Evaluate error value of the network

(3) Update the algorithm to provide proper value for network parameters

(4) Check the criteria condition

Table 4: Potential value table of retained reserves of three major minerals in three prefecture-level cities in southern Shaanxi in 2020.

Area	Total land area (KM^2)	Total population (10,000 people)	Potential value (RMB hundred million)	Ranking	Unit area potential value (RMB ten thousand)	Ranking	Potential value per capita (RMB)	Ranking
Hanzhong city	27200	321	115.53	2	42.47	2	3599.06	2
Ankang city	23529	249	64.45	3	27.37	3	2588.35	3
Shangluo city	19292	205	339.87	1	176.17	1	16579.02	1

(5) If the criteria condition is not achieved, go to (3)

(6) If the criteria condition is reached, go to (7)

(7) End

5. Comprehensive Analysis of Potential Value and Carrying Capacity of Mineral Resources in Southern Shaanxi

This paper mainly evaluates the potential value of four kinds of advantageous mineral resources in three prefecture-level cities in southern Shaanxi. The potential value of mineral resources is essentially the value of a proven available mineral resource converted from the price of its primary products, reflecting and measuring the strength and potential of mineral resources in a study area from a macro level. The potential value of mineral resources is the value of a proven available resource converted from the price of its primary product. This indicator does not deduct the mining and selection loss of mineral resources and the element cost of exploration and mining and is used to reflect the strength of mineral resources in a specific area from a macro level. The evaluation of the potential value of mineral resources is a general assessment of the potential of mineral resources and the possible economic benefits of future development. It can not only reflect the abundance of mineral resources but also reflect the economic scale of future mineral development and provide a basis for analyzing the contribution of mineral exploitation to the regional economy, and it is also an important basis for resource economic zoning.

5.1. Analysis Method

(i) Begin the neural network training

(ii) Determine the network inputs including the following:

(iii) Mineral Reserves (R): the current situation of mineral resources utilization in southern Shaanxi and local mineral records are used as the data for this calculation. By the end of 2017, the retained reserves of four major mineral resources in three prefecture-level cities in southern Shaanxi are used.

(iv) The Price of Mineral Products (P): the price of mineral products selects the latest market price of the latest raw mineral products as the calculation parameter.

(v) Grade Adjustment Coefficient (G): the grade adjustment coefficient refers to the conversion coefficient between unit mineral reserves and unit mineral products, which is obtained by dividing the average grade of mineral reserves by the mineral product grade per unit price.

The conversion formula is as follows: grade adjustment coefficient = average grade of mineral reserves ÷ mineral product grade per unit price.

5.2. Comprehensive Analysis and Evaluation of Potential Value and Economic Carrying Capacity of Major Mineral Resources in Southern Shaanxi. Mining plays a pivotal role in the development of the national economy in Shaanxi Province and southern Shaanxi. The evaluation of the potential value of mineral resources and economic carrying capacity can embody and reflect the guarantee capacity of regional mineral resources and the contribution capacity of the mineral economy to a certain extent. The capacity of mineral resources to pay for the future economic development speed is to determine the economic development speed under the condition of available resources in the future by measuring the demand for resources of the economic development speed. The carrying capacity of mineral resources for social and economic development is the degree of support to social material production and people’s life.

From Table 4 and Figures 3 and 4, it can be seen that by the end of 2020, the total potential value of retained resource reserves of the four major mineral resources in the three prefecture-level cities in southern Shaanxi was as high as RMB 51.985 billion.

The potential value, potential value per unit area, and potential value per capita of the retained reserves of the four major mineral resources in the three prefecture-level cities in southern Shaanxi are in the order of Shangluo, Hanzhong, and Ankang. Among them, the most potential value of Shangluo City is as high as RMB 33.987 billion, and the potential value per capita is RMB 16,500, ranking first in southern Shaanxi. This is mainly due to Shangluo City’s super-large gold deposits, considerable reserves of lead-zinc ore, and molybdenum ore resource. Hanzhong City ranks second, with a potential value of RMB 11.553 billion and RMB 3,599.06 per capita, thanks to the reserves of lead-zinc ore resources in Hanzhong City. Figure 5 shows the evaluation figure of the carrying capacity of mineral resource in southern Shaanxi.

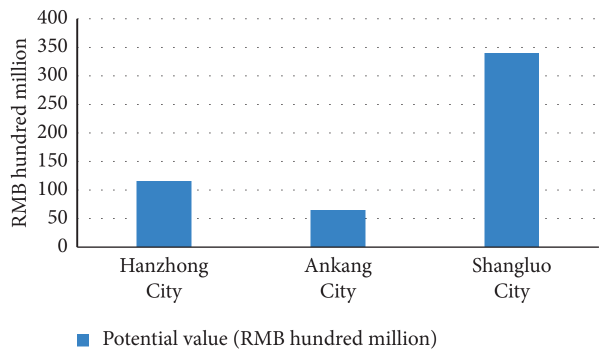

Figure 3: Histogram of potential value of mineral resources in three prefecture-level cities in southern Shaanxi.

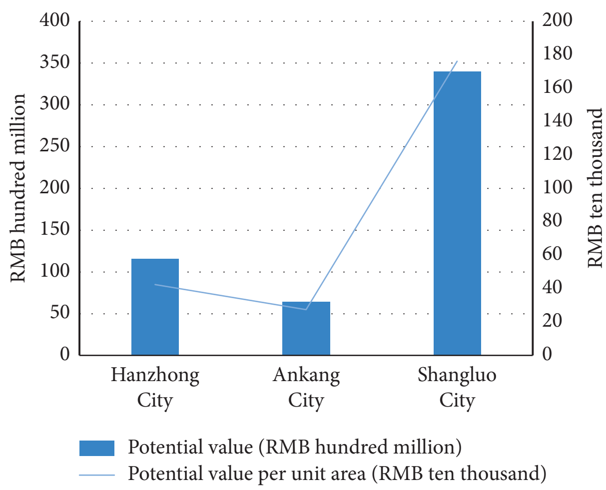

Figure 4: Comparison figure of the potential value of mineral resources and the potential value per unit area of three prefecture-level cities in southern Shaanxi.

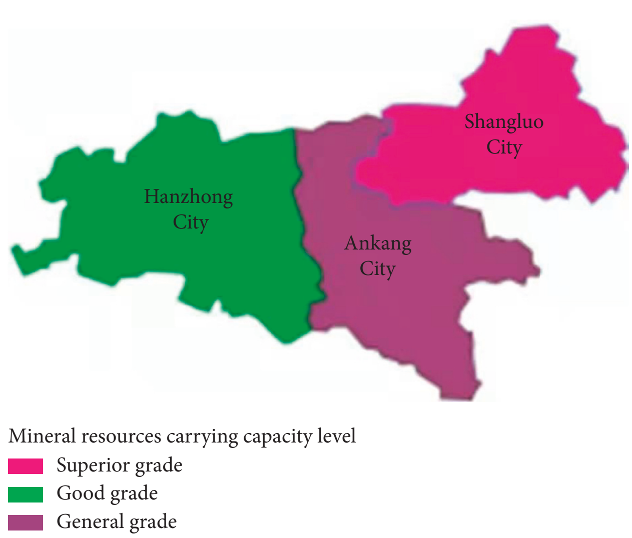

Figure 5: Evaluation figure of resources carrying capacity of mineral resource in southern Shaanxi.

Based on the analysis of the mineral advantages of the four main minerals (gold, lead, zinc, and molybdenum ore) in southern Shaanxi and the analysis of the potential value carrying capacity of mineral resources in the three prefecture-level cities, it is concluded that the grades of mineral resources carrying capacity of the three prefecture-level cities in southern Shaanxi are divided into three grades, namely: Shangluo City is an excellent grade, Hanzhong City is a good grade, and Ankang City is a general grade.

6. Conclusion and Analysis

Based on the current situation of development and utilization of advantageous mineral resources in southern Shaanxi, this paper establishes a hierarchical structure model for comprehensive evaluation of advantageous mineral resources in southern Shaanxi and draws the following conclusions:

(1) In general, the mineral resources in southern Shaanxi have an advantageous position in the follow-up carrying capacity of the national economy. Through the analysis of the distribution of minerals and the status quo of resources in this region, an analysis and evaluation model for mineral advantages based on the analytic hierarchy process is established, apply it to the research area, and the evaluation results are good, which is more in line with the actual situation.

(2) Based on the evaluation and analysis of the advantageous mineral resources, the evaluation model equation of the potential value of mineral resources in southern Shaanxi is established, and the potential value of mineral resources in the three prefecture-level cities in the study area is calculated and analyzed. The mineral resources carrying capacity in southern Shaanxi is comprehensively evaluated and graded based on this. Among the three cities in southern Shaanxi, Shangluo City has the highest mineral resources carrying capacity, which is excellent, Hanzhong City has a good carrying capacity, and Ankang City has a general carrying capacity.

(3) The development of the southern Shaanxi focuses on the coordinated development of resources, environment, and social economy, and one cannot ignore the other. It is unfeasible to only pursue economic development and ignore ecological and environmental protection, and it is unrealistic to simply protect resources and the environment without developing the economy. Therefore, seeking a reasonable development model and maximizing resource and environmental benefits are the solutions to the sustainable development of resources.

Data Availability

The data used to support the findings of this study are included in the following: Shaanxi Province Yearbook 2010–2017, Shaanxi Local Chronicle 2010–2017, and Internal data from my company (the internal data of the unit are confidential); they are accessible from the following link: https://kdocs.cn/l/cruvyphXwghM.

Conflicts of Interest

The authors declare no conflicts of interest.

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