Research on Indicators Affecting Climate based on GA-BP Neural Network

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Abstract. The economic connotation reflected by GDP index is the situation of economic growth under the green background of sustainable development theory, and reflects the coordinated development of man and nature. The team first defined GGDP, selected indicators affecting climate based on the calculation of GGDP by value loss method, and improved the model. The objective weights of indicators were calculated by entropy weight method. Finally, the correlation analysis was carried out by taking temperature and carbon dioxide emissions as evaluation indicators of climate mitigation, and the heat map was drawn. The results show that there is a strong correlation between Annual freshwater withdrawals and Changes in sulphur oxide emissions. Therefore, when GGDP is used as the main indicator to measure the health of a country or global economy, it has a measurable impact on climate mitigation. Finally, the sensitivity analysis of the model is carried out, and the robustness of the model is repeatedly verified.

Keywords: Value Loss; Robustness; Correlation Analysis; GA-BP; Grey Correlation Analysis.

1. Introduction

1.1 Background

As one of the most famous and commonly used indicators to measure a country's economic health, gross domestic product (GDP) is usually used to determine a country's purchasing power and access to credit, providing incentives for countries to optimize related policies and programs.GDP measures the monetary value of final goods and services produced in a country over a given period of time, and it counts all output produced within a country's borders.For example, a country with sufficient forest resources can increase its current GDP by cutting down trees, producing wood furniture and other related measures, despite the loss of biodiversity and other negative environmental consequences, but the measures based on this calculation and citation will not be penalized.That's how important this calculation is and how it affects production.Multilateral change is very challenging, and persuading countries to agree to this new GGDP could prove difficult. If, however, this shift starts a movement towards climate change that leads to some mitigation of the climate crisis, then the fight will be worth it.

1.2 Analysis of Specific Issues

Find a way to calculate GDP, which can replace GDP as the main indicator of economic health, and analyze its impact on climate mitigation. First, the team collected relevant indicators through the World Bank and references, and selected a representative country on each of the five continents to replace global climate impacts. Based on the value loss method to calculate GDP, the entropy weight method is used to calculate the weight, and the relationship between various indicators and GDP is analyzed. Finally, take temperature and carbon dioxide emissions as evaluation indicators for climate mitigation, conduct correlation analysis, and draw heat maps to test these indicators. Develop a model that can estimate the global impact on climate mitigation. In question 1, the research team analyzed that there is no collinearity between the climate impact index and the climate assessment index.

2. Construction of GGDP Accounting System based on Resource Value Loss Method

2.1 Data Preprocessing

We defined the concept of GGDP by referring to data from statistical websites such as the United World Bank and other references, and selected corresponding primary and secondary indicators, such as energy consumption, net loss of forest resources and nitric oxide emissions, according to the GGDP accounting system of resource value loss method. Since the greenhouse effect started in the 1990s, the team collected the change trend of different indicators in different countries from 1991 to 2020, and selected one representative country from each of the five continents to represent the overall change trend of the world. The countries chosen to represent them are the United States, China, Germany, South Africa and Australia. Therefore, our team first conducted a visual analysis of the factors affecting GGDP in five countries, so as to facilitate the subsequent calculation. The visualization results are shown in Figure 1:

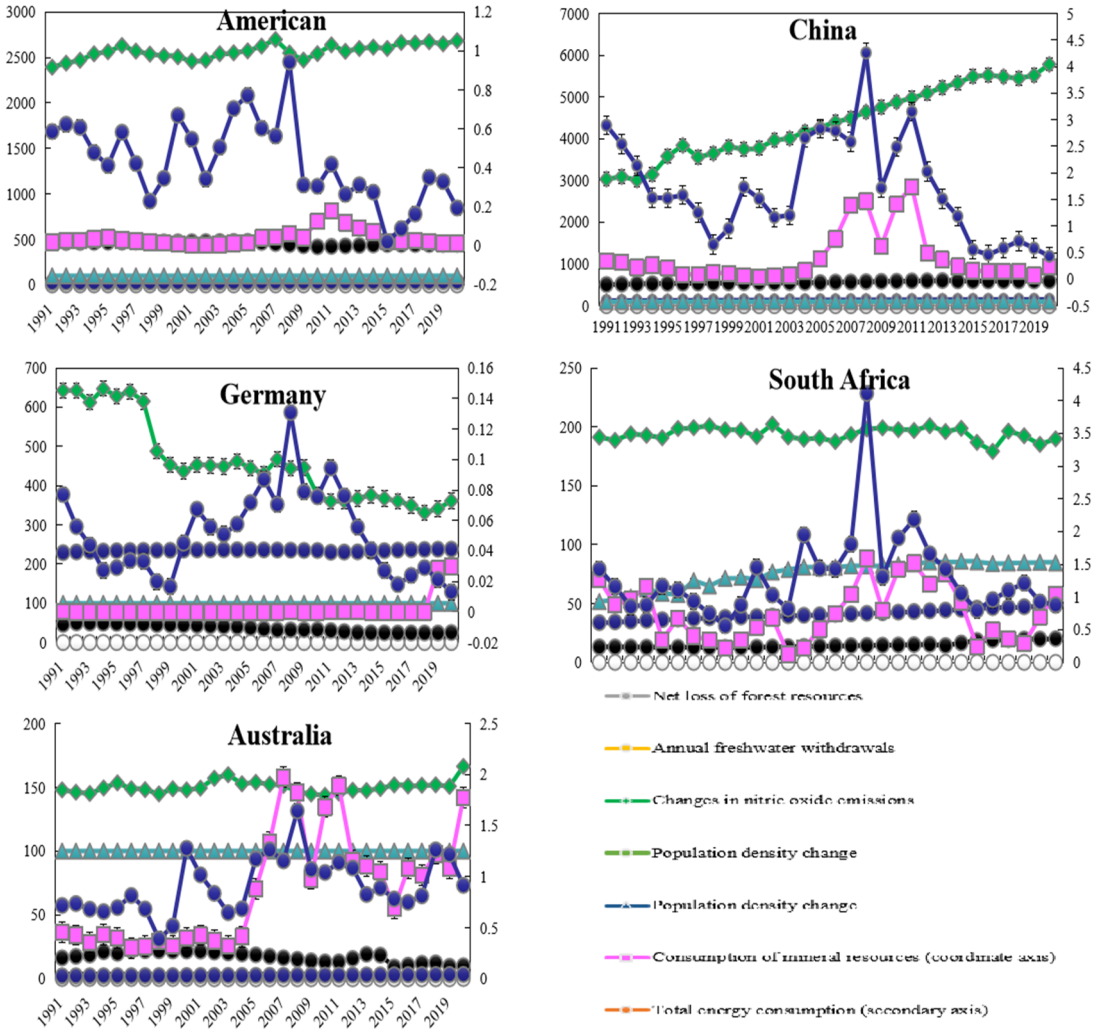


Figure 1. Visualization of influencing factors of GGDP in different representative countries

2.2 GGDP Model based on Resource Value Loss Method

GGDP is the cost left after deducting the depreciation of environmental pollution, natural resource depletion, human capital and social capital from a country's traditional GDP.It reflects the sustainability, coordination and development of economic development, and is an indicator of the harmonious degree of economic growth and nature protection.

$$GGDP = GDP - E - R \tag{1}$$

Where, is the gross domestic product, is the loss of environmental pollution, is the loss of natural resources. On this basis, this paper considers the impact of GGDP as an indicator on climate, while the loss of resource value method is used to evaluate the economic losses caused by human activities' loss of natural resources, which can be considered as the consumption cost of indirect influencing factors. Therefore, our team replaces the loss of natural resources and environmental pollution with the consumption cost of direct climate influencing factors and the consumption cost of indirect climate influencing factors, and the formula is as follows:

$$GGDP' = GDP - N - C \tag{2}$$

Where, is the consumption cost of direct climate influencing factors, and is the indirect climate influencing factors. After considering different regions of the world, our team obtained the indicators shown in Figure 2.

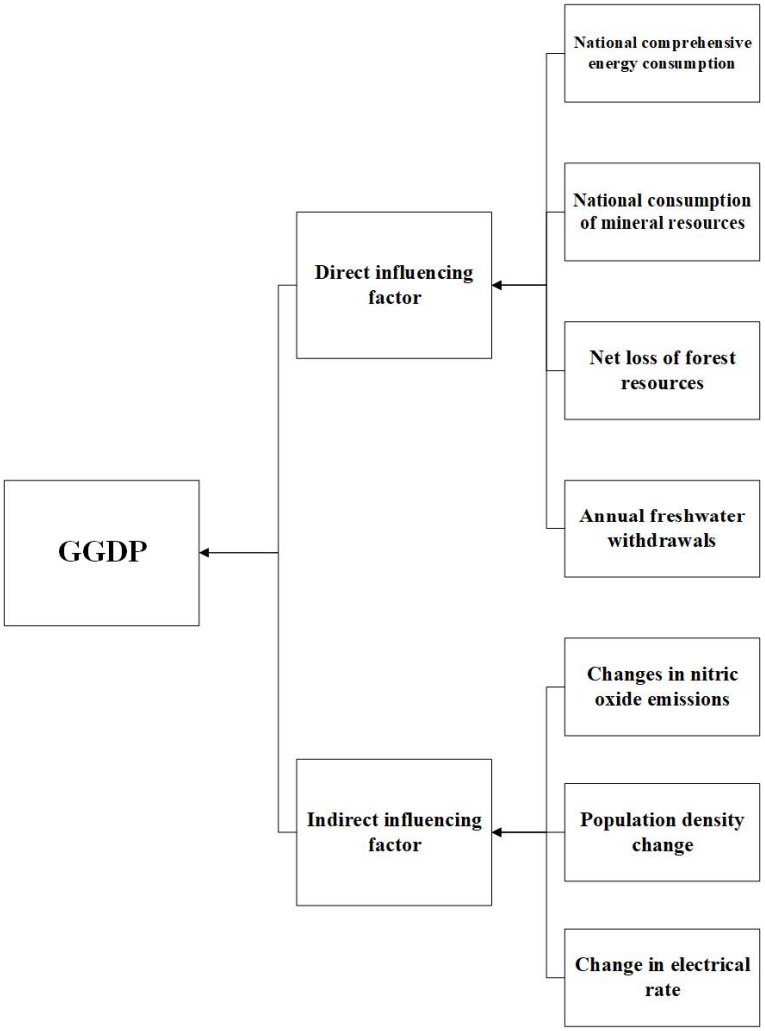


Figure 2. GGDP index system

The specific formula is:

$$\begin{aligned} N &= DMRC + DCEC + DFRC + DAFW \\ C &= InDNOE + InDPD + InDER \end{aligned} \tag{3}$$

2.3 The Weight is Calculated based on Entropy Weight Method

Step1 The probability matrix is obtained by calculating the proportion of each element in the index population, the probability matrix is defined as P, where the calculation formula for each element in P is as follows:

$$p_{ij} = \frac{\tilde{z}_{ij}}{\sum_{i=1}^{n} \tilde{z}_{ij}} \tag{4}$$

Step2 The information entropy e of each indicator is calculated, and 1-e is used to obtain the information utility value. Finally, the normalized information utility value is the weight of each indicator. The formula for calculating information entropy is:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) (j = 1,2,...,6) \tag{5}$$

Step3 The formula for calculating entropy weight is:

$$w_j = \frac{1 - e_j}{\sum (1 - e_j)} \tag{6}$$

Thus, the entropy weight of each index in this model can be obtained, as shown in Table 1:

Table 1. Index weights of each representative country

Representative country	DMRC	DCEC	DFRC	DAFW	InDNOE	InDPD	InDER
China	0.185	0.079	0.076	0.000	0.240	0.191	0.229
America	0.182	0.053	0.085	0.000	0.302	0.170	0.208
Germany	0.190	0.055	0.069	0.000	0.273	0.202	0.211
South Africa	0.216	0.161	0.045	0.000	0.168	0.214	0.195
Australia	0.170	0.128	0.069	0.160	0.277	0.048	0.147

Finally, comprehensive weight coefficients representing different countries are solved, as shown in Figure 3:

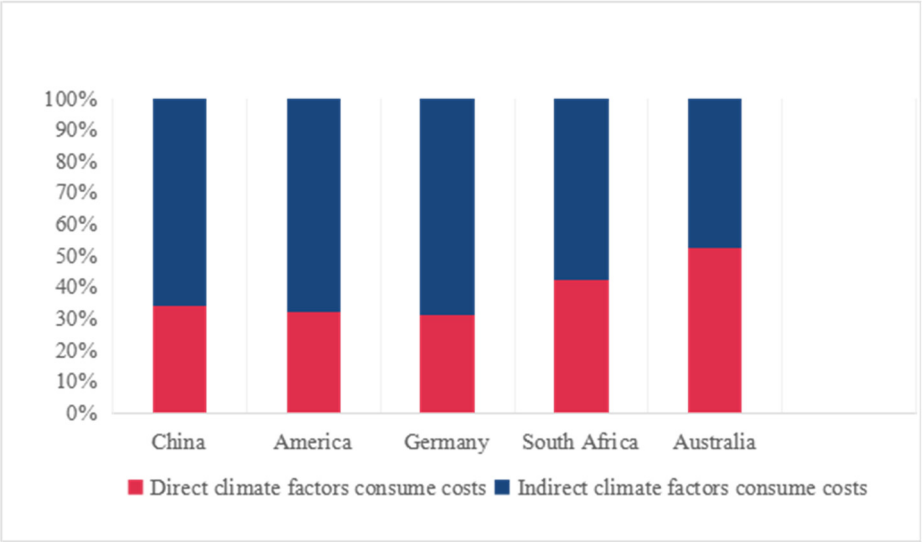


Figure 3. Weight chart of influence indicators of different countries

The weight of direct influencing factors is 0.3844 and the weight of indirect influencing factors is 0.6156. It can be seen from the figure above that the indirect factors in China, America, Germany and south Africa are significantly higher than the direct factors, while the weight of the direct factors in Australia is higher than the indirect factors. This is because Australia has significantly more forest cover than the other four countries and focuses more on the net increase of trees. Finally, the relationship between GGDP and traditional GDP of the five representative countries is solved by weight, as shown in Figure 4:

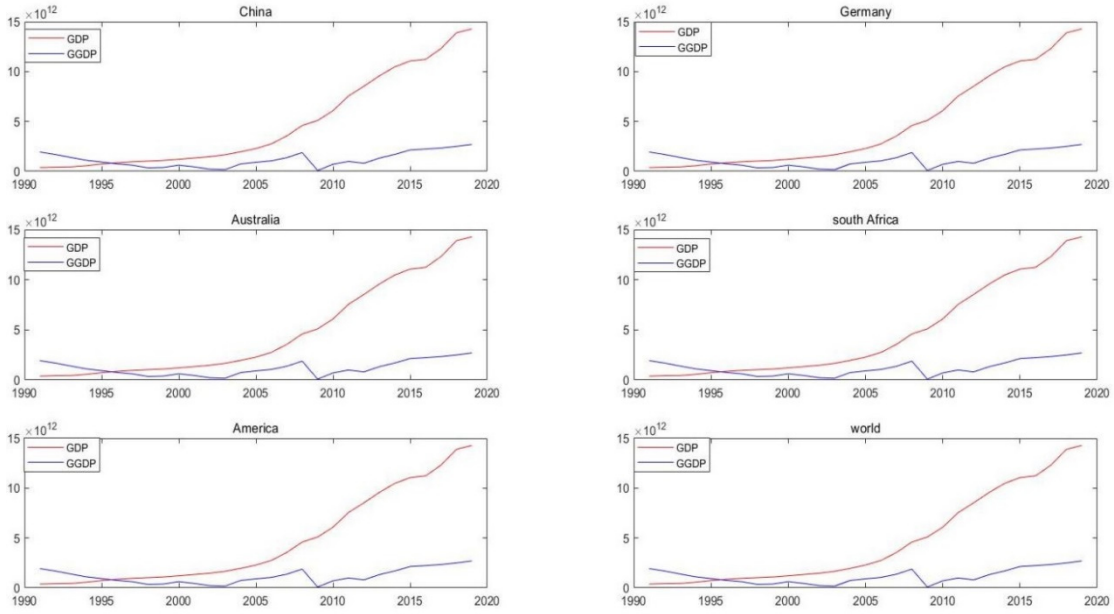


Figure 4. Relationship between GGDP and GDP

As can be seen from the figure above, the GDP of each country has been on a steady upward trend, while the upward trend of GGDP is extremely slow and accompanied by years of decline. Therefore, when GGDP is used as the main indicator to measure the health of a country or global economy, it has a measurable impact on climate mitigation.

2.4 Analysis of Climate Mitigation Effects based on Correlation Analysis Heat Maps

By referring to relevant literature, the team selected temperature and carbon dioxide emissions as climate evaluation indicators, and drew the thermal map of correlation between indicators affecting climate and climate evaluation indicators through python, as shown in Figure 5:

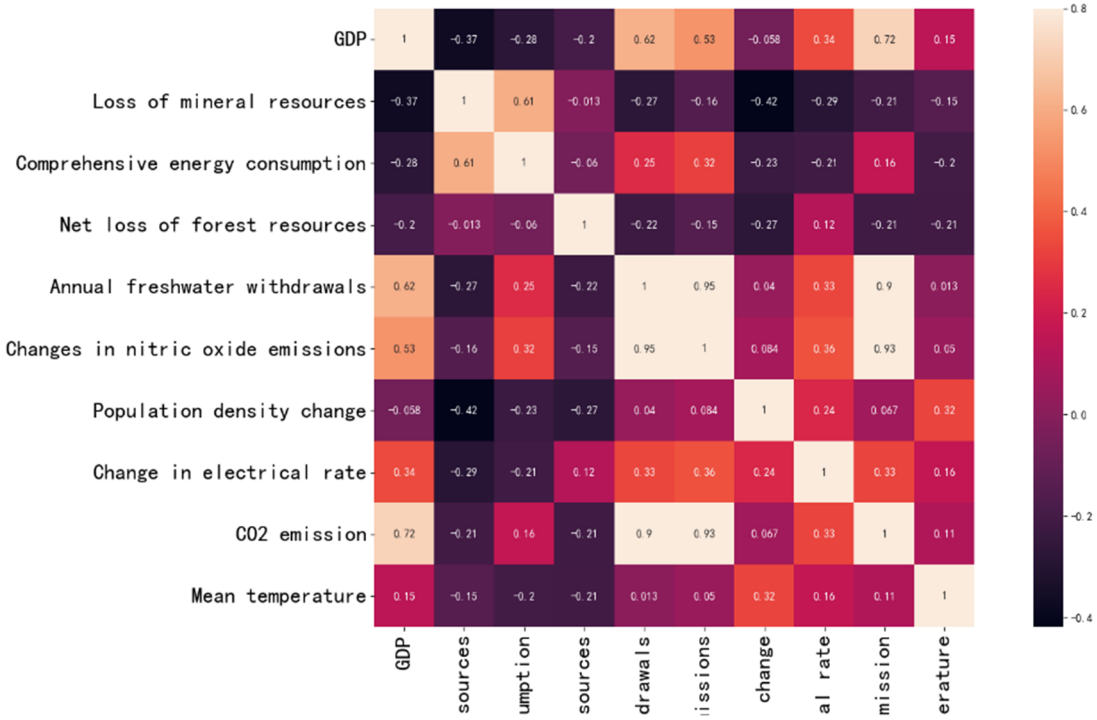


Figure 5. Heat map of correlation analysis

As can be seen from the figure above, Annual freshwater withdrawals and Changes in sulphur oxide emissions are strongly correlated with carbon dioxide emissions, while there is no index

strongly correlated with average temperature. Therefore, climate impact can be measured by the above indicators.

3. The Establishment of GA-BP Model

3.1 The Establishment of BP Neural Network Prediction Model

BP neural network is one of the most widely used neural networks. It is a kind of multi-layer feedforward network which propagates backward by error. BP neural network contains an input layer, an output layer and multiple hidden layers, as shown in Figure 6:

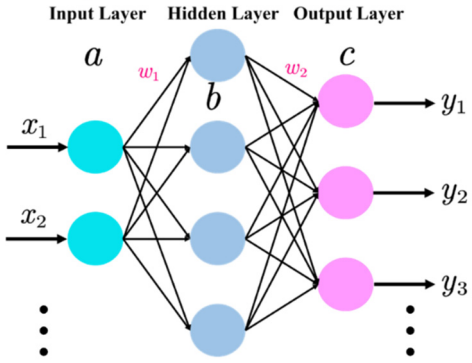


Figure 6. Schematic diagram of BP neural network

3.2 Genetic Algorithm to Optimize the Weight and Threshold of BP Neural Network

3.2.1 Population Initialization

The weight and threshold between the input layer, output layer and hidden layer of the BP neural network are carried out real number coding operation, and the real number coding is taken as the individual of the population.

3.2.2 Fitness Function Calculation

Firstly, the initial weight and threshold of the neural network are obtained through individual i, and the predicted value of the grid output is obtained after network training. Calculate the sum value of the absolute error between the predicted value and the expected value, and multiply the sum value by a correlation coefficient k to obtain the fitness value F. The formula is as follows:

$$F = k\left(\sum_{i=1}^{n} \text{abs}\left(y_i - o_i\right)\right) \tag{7}$$

3.2.3 Selective Operation

The roulette method is a selection strategy based on fitness ratio. The corresponding selection probability of each individual i is p_i:

$$\begin{aligned} f_i &= \frac{k}{F_i} \\ p_i &= \frac{f_i}{\sum_{j=1}^{N} f_j} \end{aligned} \tag{8}$$

3.2.4 Cross Operation

$$\left.\begin{aligned} \alpha_{ki} &= \alpha_{kj}(1-b) + \alpha_{1j}b \\ \alpha_{1j} &= \alpha_{1j}(1-b) + \alpha_{kj}b \end{aligned}\right\} \tag{9}$$

In the above equation, b is a random number between [0,1].

3.2.5 Mutation Operation

Select the j gene α_{ij} of the i individual and carry out mutation operation on it:

$$\alpha_{ij} = \begin{cases} \alpha_{ij} + (\alpha_{ij} - \alpha_{\max}) * f(g) & r > 0.5 \\ \alpha_{ij} + (\alpha_{\min} - \alpha_{ij}) * f(g) & r < 0.5 \end{cases} \tag{10}$$

In the formula, $f(g) = r_2\left(1 - \frac{g}{G_{\max}}\right)$, r_2 is a random number, g is the current iteration times, $G_{\max}$ is the maximum evolution times, and r is the random number between [0,1].

3.3 Design of Prediction Models

The initial weight and threshold of the network contained in the optimal individual obtained by the genetic algorithm are given to the BP neural network, and combined with the corresponding network training, the prediction results are given. The overall algorithm flow chart is shown in Figure 7:

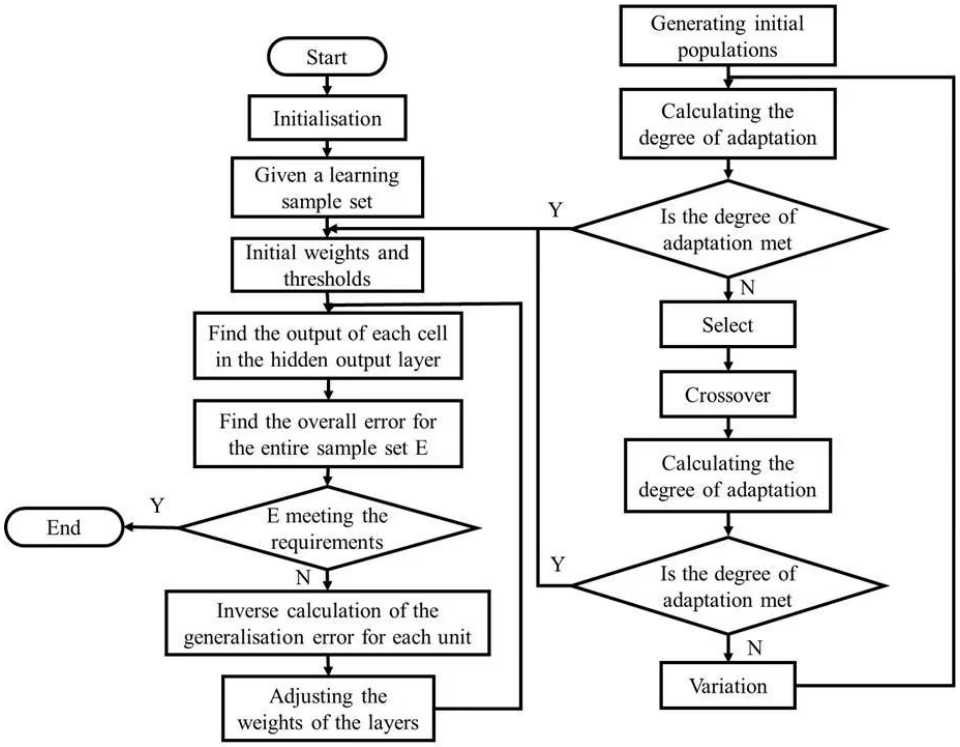


Figure 7. Flow chart of BP neural network algorithm optimized by genetic algorithm

4. Conclusion

Based on the calculation of GDP using the value loss method, this paper selects indicators that affect climate, and improves the model. The objective weight of the index is calculated using the entropy weight method. Finally, correlation analysis was conducted using temperature and carbon dioxide emissions as evaluation indicators for climate mitigation, and a heat map was drawn. The results show that there is a strong correlation between annual freshwater extraction and changes in sulfur oxide emissions. Therefore, when GDP is used as a primary indicator of the health of a country or global economy, it has a measurable impact on climate mitigation. Finally, the sensitivity analysis of the model was conducted, and the robustness of the model was repeatedly verified.

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