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Research on ecological logistics evaluation model based on BCPSGA-BP neural network

Weihui Du[1] · Xiaofen Zhou[1] · Changxiang Wang[1] · Donglin Rong[2]

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Abstract
The realization of ecological logistics evaluation model based on BCPSGA-BP neural network is beneficial to improve the level of logistics management in China, to achieve the purpose of energy saving and emission reduction, environmental protection and sustainable development. This paper discusses the construction of ecological logistics model through green logistics, agile logistics, lean logistics, reverse logistics, environmental protection logistics, recycling logistics, cleaner production and other logistics forms under the background of electronic commerce, Finally, CPSGA-BP neural network is proposed as an evaluation model to achieve the objective and accurate assessment of the ecological logistics performance model, and provides strong evidence and support for the development of ecological logistics.

Keywords Ecological logistics · BCPSGA-BP · Evaluation model

1 Introduction

With the increasing of global population and the deterioration of environment in the twenty-first century, ecological problems have become one of the hot spots in the international community. With the pace of the development of technology and the renewal of knowledge, the management mode and concept of traditional industrial economy are facing new challenges. As a traditional and ancient industry, the logistics industry is more and more impacted and baptized by new technologies and methods. As a new type of logistics, ecological logistics broadens the development space of logistics enterprises, improves the living environment of logistics industry, and finds a new development path for logistics industry [1].

In 1943, psychologist W.S.McCulloch and mathematical logic W. Pitts established the neural network and mathematical model, called the MP model. They have proposed a formal

✉ Xiaofen Zhou
zxf33079762006@126.com

1 School of logistics, Wuhan Technology and Business University, Wuhan 430065, China

2 Faculty of Information Engineering, China University of Geosciences, Wuhan 430074, China

mathematical description of neurons and a network structure method through the MP model, proving that a single neuron can perform logical functions, thus creating an era of artificial neural network research. In 1949, psychologists came up with the idea that synaptic connections could be changed in intensity. After careful analysis of the functions and limitations of the neural network system represented by the perceptron, M..Minsky published the book “Perceptron” in 1969, pointing out that the perceptron can not solve the problem of the higher order predicate. Their arguments have greatly influenced the research of neural networks, and the achievements made by the serial computers and artificial intelligence at that time concealed the necessity and urgency of developing new ways of new computers and artificial intelligence, making the research of artificial neural networks at a low tide. During this period, some researchers of artificial neural networks still work on this research, and put forward the adaptive resonance theory (ART network), self-organizing mapping, cognitive network, and the research of neural network mathematical theory. The above research lays a foundation for the research and development of neural network. In 1986, Rumelhart, Hinton, and Williams developed the BP algorithm. Rumelhart and McClelland published “Parallel distribution processing: explorations in the microstructures of cognition”. So far, the BP algorithm has been used to solve a lot of practical problems [10].

At present, domestic and foreign scholars have studied the ecological logistics from different aspects. Yang Jianhui and Pan Hong believed that ecological logistics is a better choice for modern logistics, and it is the unity of three goals of economic, social and ecological benefits, and put forward the organizational model and network structure of developing ecological logistics in China. Xu Xinqing and Cui Huibao believe that the negative impact of modern logistics activities on the environment has threatened people’s daily life. It is proposed that modern logistics should be put into consideration in the ecological system, and the development of an ecological logistics system should be promoted by establishing effective incentive and restraint mechanisms. Xu Zhizhong, Ji Jianhua studied the ecology of logistics system and the construction of urban ecological logistics system. Li Tianmin, Meng Qingxia analyzed the source and theoretical support of the recycling logistics, and explored the sustainable logistics development model and implementation strategy. Dr. Dale S. Rogers, Dr. Ronald S. Tibben-Lembke studied the trends and practices of reverse logistics, and Srinivasan M and Sheng P proposed the characteristics of green manufacturing. Although many scholars at home and abroad have studied and analyzed the situation of ecological logistics from the angles of environmental logistics, agile logistics, lean logistics, reverse logistics, environmental protection logistics, circulation logistics and so on, few studies have been carried out, and there is not much relevant literature from the point of view of constructing the ecological logistics model under the environment of electronic commerce. Taking the actual logistics production project as the starting point, this paper constructs a set of ecological logistics model based on BP to expound the significance of the ecological logistics development, and to explore the future development direction of ecological logistics through reasonable ecological logistics projects and optimization programs.

2 Construction of ecological logistics model

2.1 The concept of ecological logistics model

Ecological logistics is a kind of logistics system which uses advanced logistics technology and ecological engineering technology to plan, build and manage under the guidance of ecological principles. Based on the theory of sustainable development, the ecological logistics system is transformed from the perspective of ecological environment to form an environmental symbiotic logistics system. Its core idea is to emphasize the overall and long-term nature of the logistics system. Ecological logistics pays attention to the coordination of logistics activities and ecological benefits, and adopts the attitude and new concept of harmonious coexistence with the natural environment to recognize and identify this new form of logistics.

Ecological logistics model is an organic combination of environmental logistics, agile logistics, lean logistics, reverse logistics and circulation logistics to form a set of feasible and sustainable logistics system. The ecological development of logistics model can lessen and reduce the cost of logistics and improve the sustainable development ability of logistics enterprises. The high integration of logistics and ecology is helpful to solve the problems of environment deterioration, resource waste and other unsustainable development problems faced by our country. Increasing the compatibility of the Ecological Logistics Model enables the model to evolve from a project to a common standard and specification covering the entire logistics industry.

2.2 The implementation of ecological logistics model

Ecological Logistics Model is a complex system applied to logistics engineering, ecological engineering and other theories and methods. This paper uses the recyclable logistics and waste logistics to conduct research on the Ecological Logistics Model, establishes a suitable incubation base in rural areas, and links different incubation bases to form a network of ecological logistics circulation systems. The purpose of the incubating base is to recycle waste and dispose of the wastes in rural production and life (such as crop straw, agricultural film, domestic waste, etc.) from sources, recovery, sorting, purification, incineration, burial, etc. and the process of controlling related information for the recycling of substances.

In this model, the comprehensive utilization of solid waste in rural areas mainly includes reuse and recycling. Reuse is the recycle of the same use of waste, such as “one-film dual-use” and “one-film multi-use” of agricultural film. The recirculation is divided into the original and secondary recirculation, and the original recycling means that the solid waste is used to produce the new products of the same type, such as some electronic components in the discarded electrical apparatus; Secondary recycling is the conversion of waste into other raw materials or resources, such as biogas of animal manure and gasification of straw after physical or chemical treatment. The model and logistics process are shown in Fig. 1:

The nature of ecological logistics has been sublimated from general logistics activities to an economic management model, and the content of ecological logistics activities also covers other logistics forms. As the expression form of circulation logistics supply chain, ecological logistics has the essence of environmental logistics, circular logistics, environmental protection logistics and reverse logistics, which is the advanced stage of modern logistics development and the direction of logistics development. In environmental logistics, recycling logistics, environmental logistics and reverse logistics, it also embodies the ideas and methods of lean logistics, agile logistics and cleaner production. Their interrelationships are shown in Fig. 2 [2].

Figure 2 shows that ecological logistics consists of many logistics units, as illustrated in Tables 1 and 2.

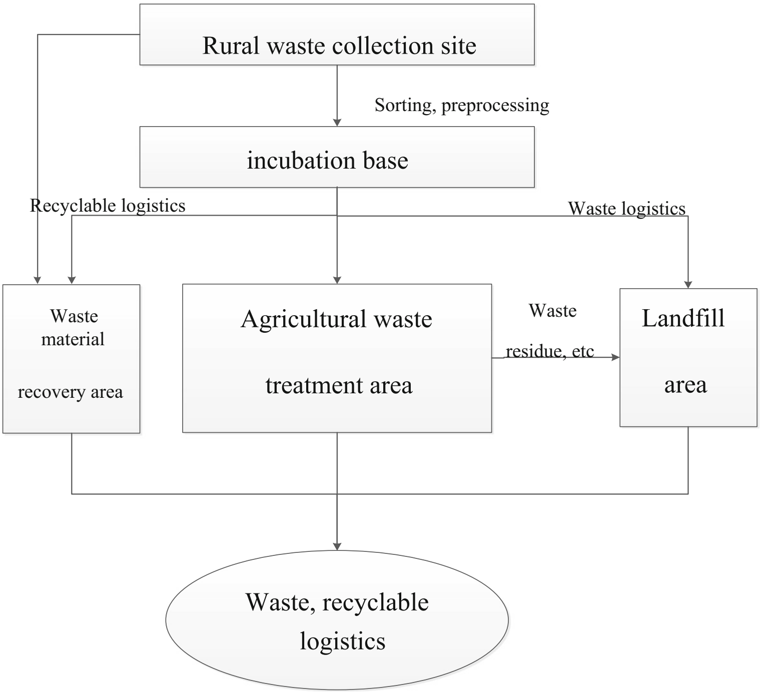

Fig. 1 Ecological logistics model chart

3 Project empirical analysis of ecological logistics model

The modern ecological logistics system includes four parts: logistics market system, production material logistics market system, life material logistics market system and production and life recovery logistics system. The development of China's ecological logistics system is to establish a logistics system that can improve resource utilization, reduce pollutant emissions, save transaction costs, improve service levels, enhance product quality, increase product sales profits, and maximize customer satisfaction and social needs.

3.1 Project planing

Ecological logistics model is embodied by incubating base. By constructing incubating base in Zhongmou County, Henan Province, the construction process of ecological logistics is demonstrated. The combination of environmental logistic logistics, lean logistics, reverse logistics, environmental logistics circulation logistics and so on, can form a feasible implementation scheme, promote the ecological development of logistics and reduce logistics cost.

The incubating base is mainly used in the initial stage of logistics model test, circulation logistics and recyclable logistics are first used in the base. In order to improve the saturation of agricultural product waste, the agricultural product waste is processed in the incubating base, and then traded and communicated through the information technology such as electronic commerce. Then, the whole township of all agricultural products

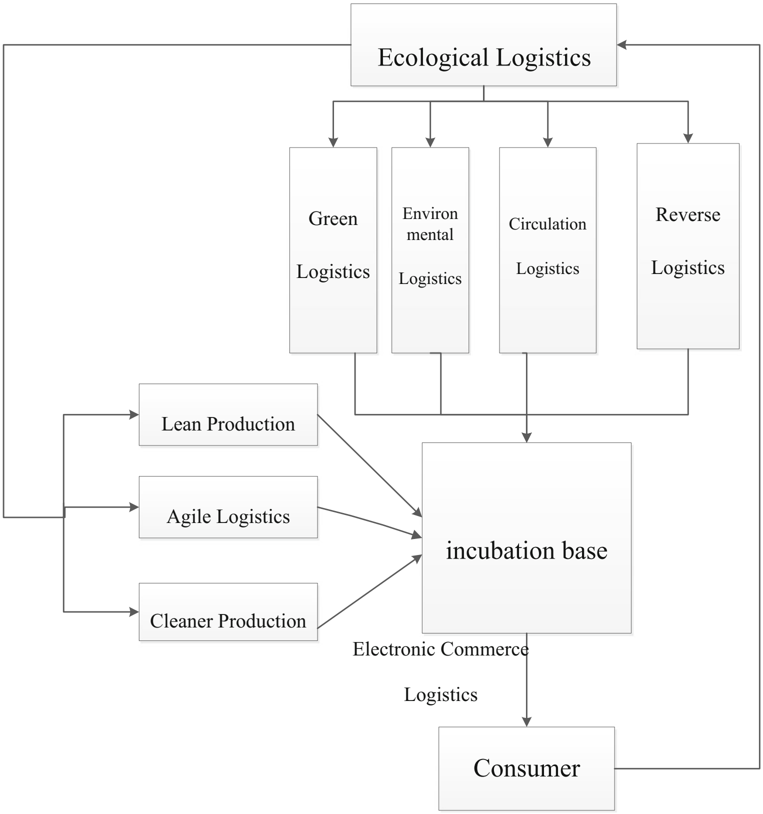

Fig. 2 Ecological logistics system interrelation

waste recovery, the development of environmental logistics, improve land use, reduce rural pollution, increase farmers' income.

In the medium stage, the incubation base can be extended to a wider range of cities and counties, each township can build a incubation base. In the future, the incubation base can not only be used as a treatment center for waste, straw of agricultural products, but also as a rural distribution logistics base with the background of E-commerce logistics. It can be used for distribution, packaging and transportation of agricultural products. It is the starting point of rural E-commerce. Connecting the hatching base into a network through electronic commerce can improve the adaptability and flexibility of the whole ecological logistics, and it is an important means to form the core competitiveness of the rural economy [3].

In the later stage, the incubation base will be pushed from the countryside to the cities and counties, and will eventually be popularized and extended in big cities and even the whole society. Ecological logistics is not only applied to the travel of people, but also includes eating, drinking, living and traveling, etc. Finally, it forms an effective, circular and sustainable ecological circle to promote the harmonious development of economy and society. The specific process is shown in the Fig. 3:

The project has different development and changes at different times, and ultimately, it is the "four in one" of logistics, energy flow, capital flow and information flow. The specific manifestations are shown in the Fig. 4 [4]:

Table 1 Comparative relationship of ecological logistics system

	System characteristics	System application
Green logistics	In the process of logistics, while restraining the harm caused by logistics to the environment, we should adopt advanced logistics technology and logistics facilities to minimize the pollution to the environment, realize the purification of the logistics environment, and improve the utilization ratio of logistics resources.	Green transport, including joint distribution, combined transport, third party logistics, etc.; green packaging, reducing the impact of product packaging on the environment; green storage; green processing; waste logistics management
Reverse logistics	Planning, implementation and control of raw materials, semi-finished products inventory, finished products and related information, efficient and cost-effectively from the point of consumption to the point of origin to achieve recovery value and appropriate disposal	Product return, material replacement, goods reuse, waste disposal, reprocessing, maintenance and remanufacturing
Circulation logistics	Achieving effective management and control of resources, providing consumers with the best interests, and bringing the best economic and social benefits for the logistics chain	Finally, the reduction of resource consumption and pollution, the improvement of logistics efficiency and the reduction of total logistics cost are realized.
Environmental logistics	Realizing customer satisfaction, connect environmental protection supply and demand main body, overcome time and space hinder goods and service flow of environmental economic management process. Environmental logistics improves the logistics system from the environmental point of view and forms an environmental symbiotic logistics management system.	The concept of sustainable development, the introduction of environmental management into the logistics system

3.2 Project introduction

In order to have an intuitive understanding of the status quo of the development of rural ecological logistics in China, the rural logistics in Yaojia Township, Zhongmu County, Henan Province was specifically investigated. Through collecting data, visiting investigation and other ways to understand and understand the basic situation of ecological logistics development in China. Yaojia Township is located on the south side of Zhongmu County. The township has a total land area of 82 km2 and a population of 31,000. The land resources are abundant. The main economic industries include aquaculture, greenhouse watermelon, strawberry, garlic and other pollution-free planting, the industrial structure shows a trend of diversified development. After collecting the data of Yaojia Township and mastering the agricultural structure, industry development trend and logistics status of Yaojia Township, this paper takes Yaojia Township as a project case to study and discuss deeply.

3.2.1 General situation of project development

(1) The logistics infrastructure is relatively complete

Table 2 Comparative relationship of ecological logistics assistant system

	System characteristics	System application
Lean production	Eliminate all waste, provide the right product at the right time, at the right place	Eliminate non-value-added waste in the production and supply process to reduce stock preparation time and provide customer-satisfied logistics services in accordance with customer needs, in the pursuit of minimizing waste and delays in the provision of logistics services, Improving the Value-added benefit of Logistics Service process
Cleaner production	Through the scientific and rationalization of product design, raw material selection, process reform, production process management, and material recycling, production with as little raw materials and energy as possible, or with alternative renewable resources, to effectively reduce pollution in the logistics process	To minimize the production of waste and its pollution to the environment in the process of logistics, and to realize the reduction of the total amount of pollutants discharged
Agile logistics	Using agile management means and techniques, sharing information, delivering the right quality and quantity of target products, distributing the right place in the right way to meet the needs of customers' individuation and mass customization, realizing fast, efficient, cost-effective and overall efficiency optimized logistics system.	Quick response, customer satisfaction, co-operation-win-win, supply chain integration, cost-efficiency. Adapt to the new market environment, make a more rapid response to the market.

The highway infrastructure in Yaojia Township is relatively perfect, with the basic conditions of logistics and transportation, and can be used as the development site of the project, but there are still many places that need to be supplemented and optimized.

(2) Single function of cooperative organization

In recent years, Zhongmou County has established more than 20 relatively mature rural cooperative organizations, such as Farmers' Brokers Associations, Refrigeration Associations, Garlic Associations, Rural Marketing Cooperatives and so on, most farmers also participate in such rural cooperative organizations. In addition, Zhongmou County also set up a marketing

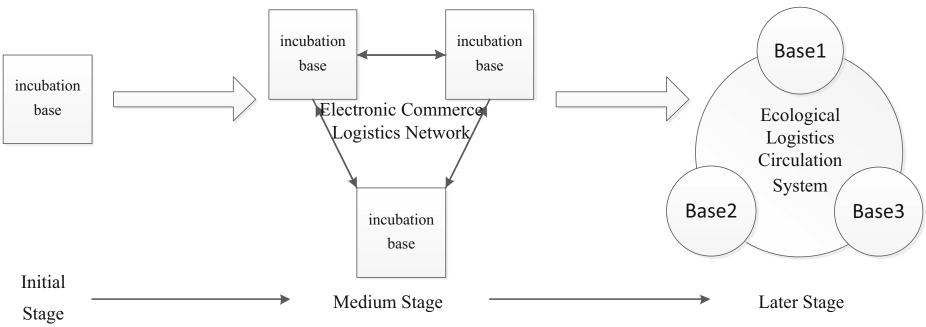

Fig. 3 Project planning process table

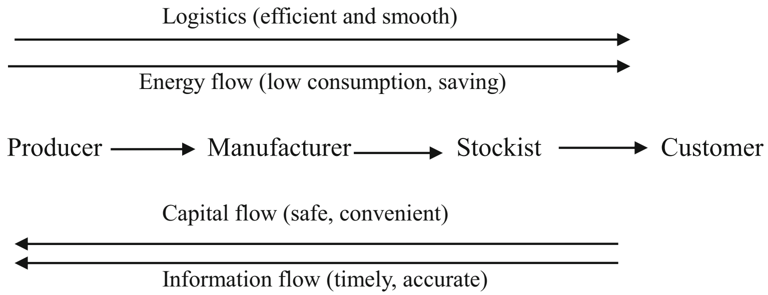

Fig. 4 Table of development planning of "four flows in one"

center for agricultural and sideline products, which is responsible for sales of agricultural and sideline products such as watermelon, garlic, peanuts, soybeans, and related production materials from Zhongmou County, which realizes the effective connection between agricultural production and urban market sales, and provides more convenient services for farmers' production, procurement and sales [5].

(3) Agricultural chain is more reasonable

The industrial structure of Yaojia Township is diversified and involves various industries such as agriculture, forestry, animal husbandry, and fishery. In recent years, the industrial structure has developed in the direction of ecological agriculture and circular agriculture. The large amount of feces produced by breeding can be used as fertilizer for agricultural production, adopting the "company + base + farmer" production and management methods, and solving the two major problems of increasing farmer income and resource utilization. At the same time, the local dehydrated vegetable project and the garlic deep processing project have lengthened the agricultural industry chain, increased the agricultural added value, increased the farmer's income. All these provide broad development space and superior conditions for the development of ecological logistics.

3.2.2 Project elements

The supporting elements of ecological logistics project mainly include: logistics infrastructure、logistics equipment and information facilities (equipment).

3.2.3 Project construction

Based on the Zhongmou County Incubation Base as an example, the factors of the scale design of the incubation base were analyzed.

According to the needs of the analysis can be refined from the following four aspects: ① Logistics production area; ② Auxiliary production areas; ③ Office living area; ④ Land reserved for development.

1. Design of Logistics Production Area Scale

Logistics production area generally includes storage and storage area, receiving and inspection area, picking operation area, distribution area. In the method of determining the scale of logistics production area, the theory of space-time consumption is a more suitable method. It takes time and space for goods to carry out operations in four working areas. The theory of space-time consumption is based on the principle of the balance of supply and demand of space-time consumption [1]. Through a certain method, the space-time resources needed by goods in each operation area are calculated, which is the space-time resources to be provided by the operation area. The mathematical models based on this principle are as follows:

$$A = \sum_{i=1}^{n} \frac{V_i \times T_i \times Q_i \times F_i}{T \times \alpha_i \times S_i}$$

Vi the average volume of goods per unit in the area of operation, Qi- average number of operations during operation time in operation area

Ti average operating time or average stay time of goods in the area of operation

Fi the time correlation coefficient of goods i in the operation area, T- time resources provided by the operation area

αi the utilization coefficient of time resources in the operation area, Si- utilization factor of space resources in operation area size of operation area required (units should be consistent in units of Vi)

For different working areas, the variables in the model are different. For the storage and storage area, it should be noted that in the model, Qi should take the turnover volume (ton or box) of a certain cargo during the year; Vi take the volume of this unit of cargo (m3), Ti takes the average residence time of this cargo in the operation area. T should be taken as a unit for one year, generally 365 days; αi generally is 1. For the other three operating areas, the average amount of work carried out by a cargo during the working day of each working day is generally taken as Qi; T generally is the working time of each working area shall be taken daily: αi should be determined according to the specific situation, generally take 70–80% [6].

2. Scale Design of Auxiliary Production Area

Auxiliary production areas generally include parking lots, transportation lines in distribution centers, greening and vehicle maintenance areas, mechanical maintenance areas and other construction facilities. The size of the logistics distribution center is 8% - 15%.

Generally speaking, the size of a car park can be quantified as follows:

$$T = k^{*}S^{*}N$$

In the above formula:

This is parking area (m2); k is the unit vehicle coefficient, usually 2–3; S is the projected area of the bicycle (m2), according to the selected projection area of the main models to determine; N is parking lot capacity.

② Line area in incubation bases

In order to ensure the good traffic order in incubation base, the principle of one-way driving and separate door entry and exit should be adopted in order to ensure the good traffic order in incubation base. The main roads in the base can be designed as bidirectional four lanes according to the internal road standards of the enterprise (extra large roads can be set up with six lanes and the minimum turning radius is not less than 15 m). The secondary trunk road is designed as two lanes, the auxiliary road is a single lane, the width of each lane is 3.5 m, and the clearance is 0.5 m. Large base road area generally occupies 12–15% of the total area.

③ Special greening area in incubation base

According to state regulations, the area covered by greening in the base should reach 30% of the total spare land area. Apart from considering the use of the space between the above areas for greening (for example, on both sides of the road, on the side of the building, etc.), at least 15 to 20% of the areas will be designated as green land.

④ Size of other construction facilities

Other construction facilities have different contents according to different regional bases, generally including vehicle maintenance area, mechanical maintenance area, etc. Its scale is mainly based on the actual situation and the scale of service objects, there is no specific specification requirements.

3. Scale Design of Office Living Area

Office living area is an area that is not directly engaged in production, logistics, warehousing or circulation processing. It generally includes: office, conference room, lounge, bathroom, dining room, etc. Office living area is generally about 5% of the base scale.

4. Development Reserve Land Scale

Considering the unpredictable factors in the development of incubation base, 3–5% of open land should be reserved for development. In the near future, it can be planned for greening or other simple building sites to facilitate planning for future development needs. After planning and designing the scale of the four aspects, the scale of the logistics base can be confirmed accurately according to the actual situation and the mutual influence factors. The scale of Zhongmou County Incubation Base can be verified according to the above method. The design of the base is carried out after the overall forecast of the local logistics, that is to say, the types and volumes of incubation base are known. During the planning year, the type and volume of goods and related parameters of the incubation base are as follows in Table 3:

By inserting the parameters in the table into the formula in (1), it can be concluded that the warehouse area of the incubation base is 40,600 m2, and the proportion of the planned warehouse area to other facility area is 3.3: 1, and the reasonable scale of the incubation base is 52,903 m2. Among them, the size of the office and living area is 2645 m2, the scale of reserved land for development is 2116 m2, and the scale of the auxiliary production area is

Table 3 Incubation base parameter

Name of Goods	Qi(t)	Vi ($m^3 \cdot 1/t$)	Ti/d	Si($m^3 \cdot m^2$)	Fi	αi
Agricultural Product	2150.083	1.31	0.4	2.52	1.03	1
Waste	3386.425	1.2	0.45	2.94	1.02	1
Other products	1630.804	1.13	0.5	2.78	1.03	1

4232 m2. In the specific planning and design stage, the area of other functional areas in incubation base can be refined according to the specific operation plan, and the whole incubation base can be obtained accurately and reasonably. Scientific planning of the scale of rural logistics incubation base is of great significance to the development of regional logistics and the rational use of rural land. Various theories are used to enhance the quantification degree of scale design and improve the accuracy of its scale, which can not only meet the demand of logistics development in a period of time, but also avoid the waste of land resources. The incubation base graphic design is shown in the following Fig. 5:

4 System optimization of ecological logistics model

4.1 System optimization of ecological logistics model

Combining ecological logistics with theories of circulation logistics, environmental logistics, and reverse logistics.

The theories of ecological economics, ecological ethics and sustainable development are the theoretical bases of ecological logistics and meet the requirements of 4R, i.e. Reduction, Reuse, Reclaim and Recycle. They are an important form of sustainable development, and together constitute a resource saving, environmental friendly ecological logistics circulatory system.

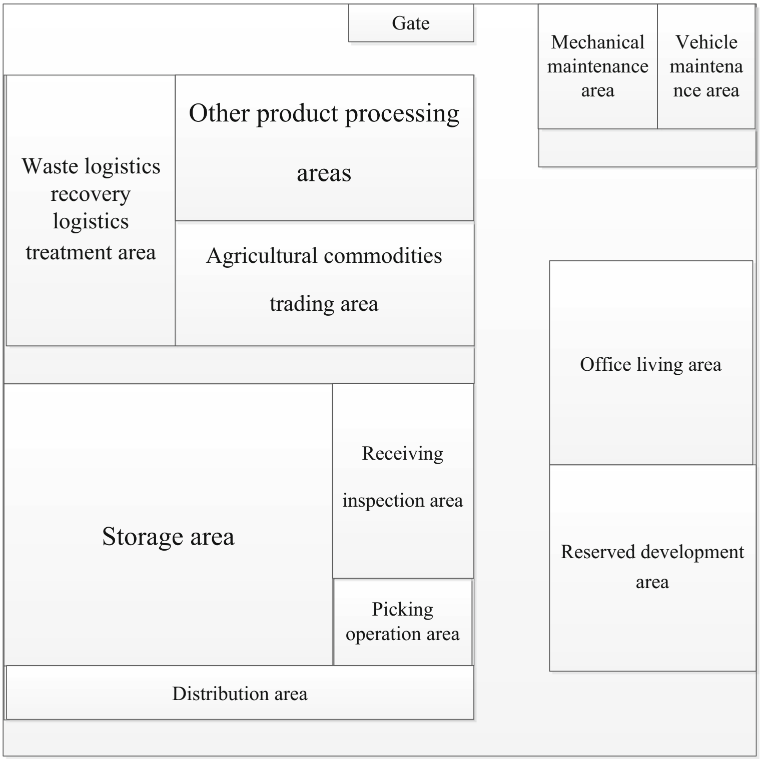

Fig. 5 Plane design of incubation base

4.2 The relationship between ecological logistics and sustainable development logistics and circular economy

When ecological logistics is integrated into the concept of sustainable development, the management of the environment naturally becomes an important part of the logistics system. It is a new logistics form to emphasize the attention to the environment and the overall and long-term benefits of the logistics system. Sustainable development is a multi-level concept, which includes E-commerce logistics, environmental recovery logistics and sustainable ecological logistics. As shown in the Fig. 6:

It should be noted that there is a difference between environmental recycling logistics and Reverse logistics. Environmental recycling logistics is not only an economic driving center in this system, but also a very important link in ecological logistics. Reverse logistics can be divided into two fields according to the objects it deals with. Most of the activities related to packaging can be classified as environmental logistics. In the sustainable ecological logistics, the electronic commerce logistics platform can be used as the background to create the ecological logistics circulatory system. Some sustainable new energy sources, such as wind energy, solar energy and so on, can be traded using sustainable ecological logistics. In this way, the energy flow loss in rural areas can be controlled in a low degree, and energy conservation and environmental protection can be achieved [7].

5 Research on ecological logistics evaluation model based on CPSGA-BP neural network

The scientific and reliable assessment model is an important guarantee to obtain accurate assessment results. In the previous research of logistics evaluation, mathematical model weighted evaluation methods such as fuzzy analysis, principal component analysis and analytic hierarchy process were used. These methods have more or less problems such as inability to handle non-linear problems, loss of information amount, and subjectiveness in the

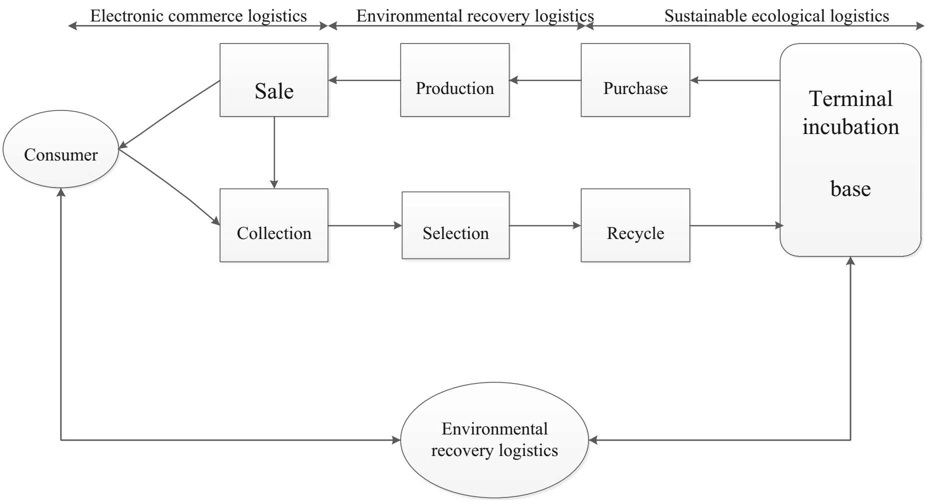

Fig. 6 The relationship between ecological logistics circulation system

process to ascertain weight. When an ecological logistics performance model is established, taking into account the full use of assessment indicator information, avoiding subjective factors affecting assessment results, CPSGA-BP neural network is proposed as an evaluation model to achieve the objective and accurate assessment of the ecological logistics performance model.

5.1 BP neural network

The multi-layer forward neural network based on BP algorithm (error back propagation algorithm) is one of the most widely studied and applied artificial neural network models.

During the learning process of the BP neural network, the connection weights between layers are continuously corrected by back propagation of errors, which reflects a strong ability for self-learning and self-adaptation; the BP neural network stores information on the distribution on neurons themselves and between neurons. Information is distributed on the entire neural network according to content, showing the characteristics of distributed storage, which makes it obtain a better fault tolerance. Even if some information is damaged or lost, the network can still restore complete information and maintain normal operation; at the same time, the information processing in the BP neural network is mainly distributed in parallel, which is more efficient than serial processing. Figure 7 is showed a cartoon drawing of biological neurons in the human brain [8].

5.2 The BP neural network optimized by CPSGA algorithm

Considering that the BP neural network is prone to falling into local minimums and that the instability of generalization ability will directly affect the accuracy of the model results, this article adopts the CPSGA algorithm (Clustering Predicatory Strategies Genetic Algorithm),that is optimization of the BP neural network by the genetic algorithm of clustering ideas and predation strategies, to avoid the model falling into the local minimum value and improve the generalization ability of the model and guarantee the correctness and stability of the evaluation result.

Based on the genetic algorithm, this paper proposes a genetic algorithm based on clustering idea and predator strategy, which aims at coordinating the algorithm's premature convergence and convergence speed, balancing the algorithm's global search ability and local search ability. The algorithm improves the selection operator based on the clustering idea, and introduces adaptive crossover probability and mutation probability according to the predation strategy. On

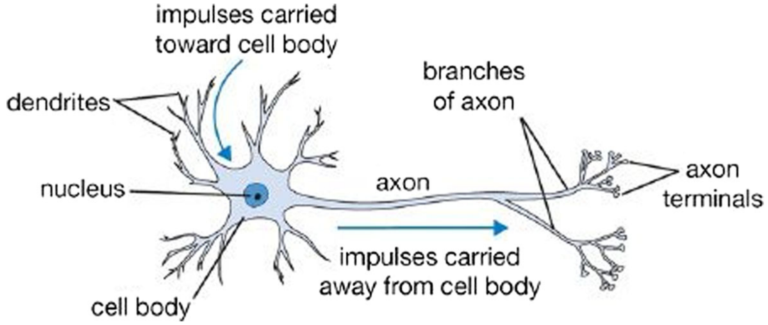

Fig. 7 Neurons in the human brain

the premise of ensuring the global search performance of the genetic algorithm, premature convergence can be avoided, and the local search ability can be improved, thereby improving the search efficiency and performance of the algorithm [9].

The global advantage of CPSGA algorithm is utilized to optimize the initial weights and thresholds of BP neural networks, which further improves the learning efficiency and stability of the algorithm. The diagrams of combination of the two are shown in the Fig. 8. In summary, CPSGA algorithm is combined with BP neural network, which can complement each other and improve the performance of the algorithm [11].

5.3 Establishment of evaluation model of ecological logistics based on CPSGA-BP neural network

Ecological logistics evaluation is a complex and nonlinear system problem. The CPSGA-BP neural network integrates the advantages of the CPSGA algorithm and the BP neural network, which has a greater advantage over other methods in dealing with nonlinear system problems. So there are unique solutions to deal with system evaluation. Therefore, CPSGA-BP neural network is taken as the evaluation model of ecological logistics in this paper.

5.3.1 The design of model structure of CPSGA-BP neural network

The BP neural network consists of input layer, implicit layer, and output layer, as illustrated in Table 4. According to the Kolmogorov theorem, the three-layer BP neural network (include only one hidden layer) can be used to approximate any nonlinear function. That is, the three-layer BP neural network can solve all mapping problems from input to output. Therefore, the CPSGA-BP neural network evaluation model established in this article is a three-layer BP neural network.

In the researches of ecological logistics which take the CPSGA-BP neural network as the assessment method, the input data of input layer of neural network is the ecological logistics

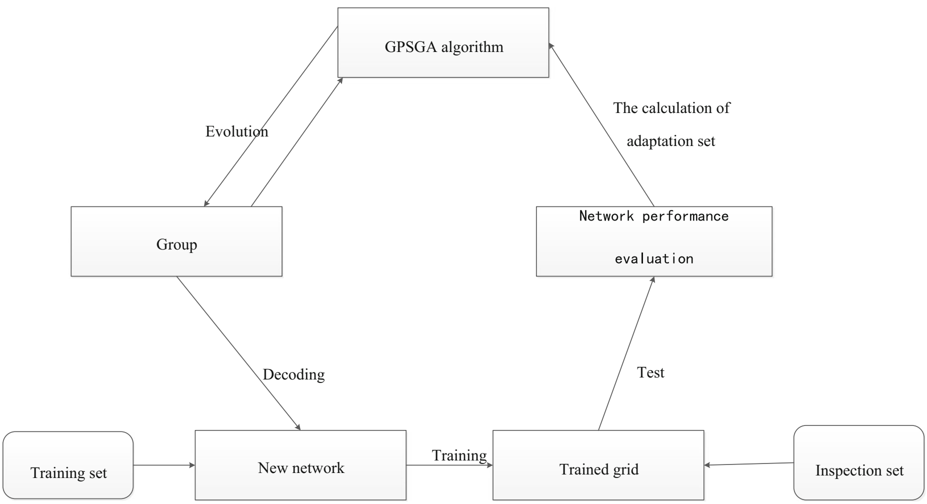

Fig. 8 The schematic diagram of combination of CPSGA algorithm and BP neural network

Table 4 Ecological logistics performance evaluation index system

Input layer	Hidden layer	Output layer
Ecological logistics performance evaluation index system	Economic benefits	Material recycling economy income
		Material recycling economic costs
		Material recycling economy savings
		Material circulation economy repetition amount
	Social benefits	The utilization rate of resource
		The utilization rate of material recycling
		The economic ratio of ecological logistics
		The occupancy rate of ecological logistics
	Environmental benefits	The savings of environmental protection cost
		Pollutant emission levels
		The input amount of environmental protection costs
		Recyclables efficiency

performance evaluation index system, and the expected output data of the output layer is the corresponding ecological logistics benefit and.

The ecological logistics performance evaluation index system is established, including 16 indicators in three areas. Hence, the number of neurons of input layer in the CPSGA-BP neural network evaluation model is 16: X (X1, X2,..., Xi).

In order to express and describe the assessment status of ecological logistics more clearly, the number of neurons at the output layer of the CPSGA-BP neural network evaluation model are designed to be 12: Y = (Y1, Y2, ... Yi.).Where, Ya represents the evaluation result of ecological logistics, whose value range is from 0 to 1. The closer to Y1, the better the ecological environment is. Yb represents economic benefit, social benefit, and environmental benefit, respectively, whose value ranges are from 0 to 1. The closer to 1, the better the indicator is. The grading standard is the same as the grading standard for ecological logistics evaluation, the grading of ecological environment is as illustrated Table 5.

It is a more complex issue to determining the number of neurons in the hidden layer. Generally speaking, the larger the number of Hidden layer neurons, the higher the accuracy of model results. However, what followed is the increase in the calculation amount of model, which will affect the learning efficiency of the model. At present, the commonly used method is that the number of neurons in hidden layer is calculated by empirical formula after the number of neurons in the input layer and the number n of neurons in the output layer are determined.

$$\mathrm{S} = \sqrt{0.43\mathrm{mn} + 0.12n^2 + 2.54m + 0.77n + 0.35} + 0.51 \tag{1}$$

According to the formula, the number of neurons in the hidden layer of the township ecological environment assessment model is 9。.

Table 5 The grading of ecological environment

Level	Excellent	Good	General	Relatively Poor	Poor
Value range	[0.8,1]	[0.7,0.8)	[0.6,0.7)	[0.5,0.6)	[0,0.5)

5.3.2 The composition of CPSGA-BP neural network model

1. Encoding method

It is an optimization problem of continuous parameter to learn BP neural network connection weights. Compared with the commonly used binary encoding method, real number encoding does not require to carry out conversion between binary and real numbers, which simplifies the calculation process. And real number encoding algorithm has higher accuracy in solving continuous problems, so we choose real number encoding method. A string array is made up of various connection weights in a certain order by real numbers encode. Each part of the string array corresponds to each connection weight in the neural network. In the CPSGA-BP neural network evaluation model, the connection weight from the input layer to the hidden layer is represented by the matrix X $(X_1, X_2, ..., X_i)^T$. The connection weights from hidden layer to output layer are represented by the matrix $Y = (Y_1, Y_2, \ldots, Y_{12})^T$. By using real number encoding, the encoding mapping can be expressed as $V = [X_1, X_2, ..., Y_1 ..., Y_{12}]$

2. Population initialization

The population size, which is set when the population is initialized, will directly affect the executive results and efficiency of the CPSGA algorithm. The larger the population, the higher the accuracy of the algorithm. However, with the increase of population size, the calculated amount of the algorithm also increases. Therefore, after comprehensively considering the accuracy requirements of the algorithm and the size of the calculation, the population size for the evaluation model is set to 100.When initializing the population, the generated population individuals need to assign initial weights which takes a random number between (−1, 1).

3. Fitness function design

The individual fitness evaluation in CPSGA algorithm depends on the fitness function of the algorithm. The greater the fitness, the closer the individual is to the global optimal solution. The individual evaluation in the CPSGA algorithm consider no other external factors, and relies entirely on the fitness function. Therefore, the proper fitness function has an important influence on the performance of the CPSGA algorithm [11].

In general, the fitness function is converted by the objective function. In the CPSGA-BP neural network model, the objective function of BP Neural network is the error function of formula (1–1). The error function is used to describe the learning situation of the algorithm by the BP algorithm. The smaller target function means the smaller network error and the higher performance of the algorithm, which corresponds to individual with the greater fitness value in the CPSGA algorithm. So the fitness function should take the reciprocal of the objective function. That is, the formula for evaluating model fitness f is:

$$\mathrm{f} = \frac{1}{e} = \frac{1}{\frac{1}{2}\sum_{i=1}^{n_k}\left(D_i - Y_i^k\right)^2}$$

In addition, in order to ensure the heterogeneity of the fitness value and the population diversity, the exponential transformation method is used by the evaluation model to transform the fitness function scale and improve the performance of the CPSGA algorithm. The transformation formula is:

$$F = e^{-bf}$$

Where B is a constant to determine selective compulsion. When the constant b takes a small value, the greater the difference in fitness between individual individuals, the stronger the competitiveness that individuals with higher original fitness values have. And their probability to be selected is increased.

4. Genetic operator design
(1) Selection operator

The basic design idea of the selection operator is to make the individuals with higher fitness have a higher genetic probability than the individuals with lower fitness. In order to avoid the premature phenomenon of inbreeding, the selection operator based on clustering idea is used by the evaluation model constructed in this paper, which divides the population into different subgroups. Genetic manipulation is performed in individuals of different subgroups, which reduces inbreeding among similar individuals and inhibits prematurity.

In the evaluation model of this paper, an adaptive minimum spanning tree method is used to design the selection operator to avoid the influence of parameter values on the clustering results. The clustering method of adaptive minimum spanning tree takes the distance between individuals and determines the number of clustering adaptively without need to artificially set the number of clustering; by dividing the individual spacing, the similarity degree of the individual in various subgroups is ensured as large as possible. But the similarity between different subgroups is small. On this basis, considering that the randomness of selection may lose the best adaptive individuals in the population, the selection operator is further improved by the evaluation model. After the population is divided into several subgroups according to adaptive minimum spanning tree, the adaptive ratio method is used to select two individuals from the population. If the two selected individuals belong to the same subgroup, the individuals with lower fitness value are discarded. The fitness ratio method is use continuously to select another individual until two selected individuals belong to different subgroups. Then the optimal individuals of two individual population are respectively selected as the parent to carry out the genetic operation. Such a selection operator can ensure individuals with better adaptability to involve in genetic evolution as possible to improve the performance of the algorithm when avoiding inbreeding [12].

(2) Crossover operator

The crossover operator can generate a large number of new individuals, which is the basis for producing individuals with better fitness and is also an important factor influencing global search. Considering that the coding model of the evaluation model constructed in this paper is real number encoding, the uniform arithmetic crossover method is selected as the crossover operator. Assuming that the two parent individuals of the t-th generation are Xt1 and Xt2, the two new individuals generated after the arithmetic crossover operation can be expressed as;

$$\begin{cases} X_1^{t+1} = aX_2^t + (1-a)X_1^t \\ X_2^{t+1} = aX_1^t + (1-a)X_2^t \end{cases}$$

Where, usually a∈[0,1], which ensures that the newly generated offspring individuals are all within the feasible area.

The dynamic crossover operators is designed by the assessment model constructed in this paper according to predatory strategies. In the initial stage of the algorithm, a global search is performed with a large cross probability pc1, and the crossover probability Pc1 changes dynamically with the evolution algebra. When the global search is converted to the local search, local search is performed with a smaller cross probability Pc2, which ensures the convergence of the algorithm. Assuming that 1 is the current evolutionary algebra, M is the total evolutionary algebra, and the dynamic variation rule of cross probability Pc1 in global search can be expressed as follows:

$$P_{C1} = P_{C1max} - \frac{(P_{C1max} - P_{c1min})*i}{M}$$

(3) Mutation operator

The new individual can be produced by mutation operator, which is conductive to improve the local search ability of the algorithm. The mutation operator is centered on the current value, and randomly disturbed in a small area near it. The individual is assumed to be [$U = u_1, u_2$ ..., u_k ...u_i], where u_k is the variation point and its range is [$U^k_{\min}$, $U^k_{\max}$]. After the mutation operation, the new individual obtained is [$U = u_1, u_2 ... u_k ... u_i$]. The variation point u_k can be expressed as:

$$U_k = \begin{cases} u_k + k*\left(U^k_{max} - u_k\right)*\gamma & \alpha \geq 0.5 \\ u_k - k*\left(u_k - U^k_{min}\right)*\gamma & \alpha < 0.5 \end{cases}$$

Where, k is a coefficient, and k∈[0,1], α,γ are random numbers on [0,1].

The mutation operator is designed by the evaluation model constructed in this paper according to the Predator strategy. In the initial phase of the algorithm is mainly the main global search, and mutation probability at this time is relatively small. With the increasing of evolutionary algebra, the mutation probability of pmt. increases to suppress the premature convergence of the algorithm. When the algorithm is converted from global search to local search, a larger mutation probability Pm1 is used to carry out local search, which ensures the local search ability of the algorithm. The law of dynamic variation of mutation probability P_{m1} with evolutionary algebra in global search can be expressed as:

$$P_{m1} = P_{m1min} + \frac{(P_{m1max} - P_{m1min})*i}{M}$$

In the implementation process of CPSGA algorithm, population fitness status g is calculated to represent optimal fitness.

Compared with the optimal degree of adaptation in the past, whether the algorithm is in local search is judged to determine the current crossover probability and mutation probability. If g > k, then the local optimization is carried out, optimization algebra is S, and the crossover probability and mutation probability at this time respectively take PC1 and Pm1; if g < k, whether the local optimization s generation is complete is determined. If not yet completed, the crossover probability and mutation probability are still taken as PC2 and Pm2. Otherwise, the crossover probability and mutation probability are PC1 and Pm1. The values of Pc1 and Pm1 are dynamically updated according to formulas until the suitable crossover probability and mutation probability are found [13].

(4) The combination of optimal solution and BP neural network

The optimal solution obtained by CPSGA algorithm is the optimal weights and thresholds which make the BP neural network have the least error. This set of optimal weights and thresholds are brought into the BP neural Network for learning and training, which can not only improve the problem that BP neural network is easy to fall into local optimum, but also improve the generalization ability of BP neural network.

5.3.3 The algorithm flow of CPSGA-BP neural network model

In the above, how to combine and optimize the CPSGA-BP neural network model algorithm under the BP neural network is analyzed, and we put forward the selection operator, crossover operator and mutation operator to make reasonable calculation and optimization. So in the section below, we rationalize the fitness evaluation by looking for the appropriate data in the population. In the CPSGA algorithm, a suitable pointcut of BP neural network is found through multiple iterative computation. The appropriate network structure is chosen in the BP neural network. The network is initialized first, and the optimal weights and thresholds are found in the large data networks in the structure algorithm. In the study of BP algorithm, whether the data satisfies the appropriate precision is verified. If satisfied, then the corresponding output validation processing is carried out. If not satisfied, the iterative calculation is continued until the appropriate precision termination calculation is satisfied. The algorithm flow of CPSGA-BP neural network model that is formed finally is shown in the Fig. 9:

5.3.4 Validation of CPSGA-BP neural network model

The validation of model is to judge the degree of conformity between the evaluation results and the real results of ecological logistics assessment model, which is used to test the accuracy of the model.

In order to verify the validity of the model, the 40 effective sample data are randomly divided into two parts. One is a training dataset, consisting of 30 sets of sample data, and the other is test datasets, including 10 sets of sample data. The experimental steps are as follows: the CPSGA-BP neural network model is initialized, the initial population size is set to 100, the genetic algebra is set to 100, and the minimum error of BP neural network is set to 0.05; the training Sample set is input, the model obtained by training the network is recorded as N1, and 10 sample data in the test data set enters evaluation model N1 to calculate the model output results. In this paper, the relative error is used to measure the validity of the model, and the calculation formula M1 is:

$$\mathrm{E} = \frac{1}{n} * \sum_{i=1}^{n} \frac{|y_i - d_i|}{d_i}$$

Where E is the average relative error of the test sample data, y_i is the actual output result of the model, and d_i is the real result of the sample data.

The obtained output results are used to calculate the average relative error of the model according to the above formula, and the results are shown in the Table 6.

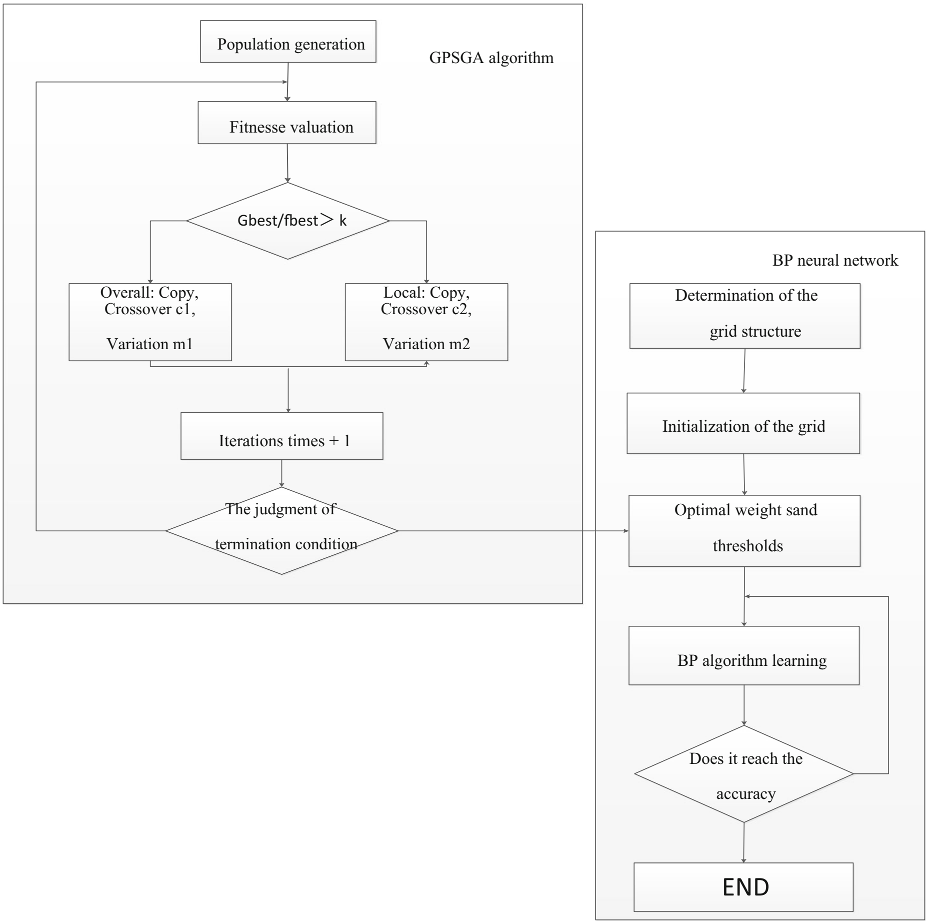

Fig. 9 The algorithm model of CPSGA-BP neural network

As shown in Table 6 above, the evaluation model N1 has a good performance on the test data set, the maximum relative error is 7.26%, the minimum relative error is 4.01%, and the average relative error of the model is 5.94%. It shows that when the CPSGA-BP neural network evaluation model is applied to the ecological logistics evaluation, the average accuracy of the model evaluation results can reach 94.06%, and the model precision satisfies the experimental demand. And it is proved that the CPSGA-BP evaluation model is effective in the assessment of ecological logistics, the model evaluation result is accurate, and the ecological logistics evaluation model is effective under BP neural network.

5.3.5 Model comparison verification

The validity of the model is verified and the stability of the model is analyzed in the first two sections of this paper. And it is proved that the application of CPSGA-BP neural network model in the evaluation of township ecological environment is feasible, and the model evaluation results are accurate and reliable.

Table 6 The relative error result table of CPSGA-BP neural network model

Test data	Relative error	Average relative error
1	4.84%	5.94%
2	4.68%	
3	6.99%	
4	7.26%	
5	6.77%	
6	6.82%	
7	5.83%	
8	5.08%	
9	4.01%	
10	7.15%	

Since the CPSGA-BP neural network model is optimized by the CPSGA algorithm of BP neural Network, this section tries to design comparative experiments from two perspective of the validity and stability of the model, and compares the performance of the CPSGA-BP neural network model and the BP Neural network model on the test data set.

In order to ensure that the experimental results are not affected by the sample data and other parameters of the model, the same training sample data and the test sample data as the first two sections are used in the comparison experiment. CPSGA-BP Neural network and BP Neural network are initialized, and both network size and initial parameters are set exactly the same. Firstly, the BP neural network is completed to obtain the model M1 mentioned above, and 10 sets of test data are introduced into the model M1. 10 sets of output data of the model are obtained and the relative errors of each group are calculated separately [14].

According to the data in Table 7, the average relative error of CPSGA-BP neural network model is 5.94%, and the relative average error of BP neural network model is 8.03%.And their difference is 2.09%. For a single data, the relative error of the CPSGA-BP neural network model is 4.01%–7.26%, and the relative error of BP neural network model is 5.61%—10.64%.

It can be observed that in the 10 test data, the relative error of the tenth group of BP Neural Networks is significantly smaller than that of the CPSGA-BP neural network model.3, 5, and 7 sets of test data of two model have nearly same relative error. In addition to the six sets of test data, the relative error of the CPSGA-BP neural network model is significantly smaller than that of the BP neural network model. Therefore, it can be considered that the CPSGA-BP

Table 7 Comparison table of relative errors between CPSGA-BP neural network and BP neural network

Test data	Relative error of CPSGA-BP neural network	Average relative error	Relative error of BP neural network	Average relative error
1	4.84%	5.94%	9.04%	8.03%
2	4.68%		10.64%	
3	6.99%		6.76%	
4	7.26%		9.75%	
5	6.77%		6.46%	
6	6.82%		8.98%	
7	5.83%		6.37%	
8	5.08%		7.33%	
9	4.01%		9.32%	
10	7.15%		5.61%	

Table 8 Test sample table

	N1	N2	N3	N4	N5	Average relative error	Standard deviation
1	5.08%	5.49%	5.37%	5.78%	5.55%	5.45%	0.002297
2	4.84%	4.37%	5.05%	5.17%	4.51%	4.79%	0.003064
3	5.83%	5.57%	4.32%	4.96%	5.64%	5.26%	0.005548
4	6.77%	6.97%	5.54%	5.62%	5.93%	6.17%	0.005928
5	4.68%	5.21%	5.21%	5.07%	4.60%	4.95%	0.002626

neural network model is superior to the BP neural network model from the perspective of the accuracy of the model evaluation results.

On this basis, 4 BP neural network models are trained continuously, and respectively recorded as M2, M3. M4 and M5, and constitute 5 BP neural network models to be evaluated together with M1. 5 sets of test samples selected in the following columns are used to test five BP neural network models from M1 to M5, and obtain the model output results. The standard deviation of the relative error of test data of various group is calculated and compared with the five sets of results produced by the CPSGA-BP neural network model, as shown in Table 8.

By comparing any set of the test data in Table 9, it can be found that the standard deviation of the CPSGA-BP neural network model is less than that of the BP neural network model. After observing the standard deviation of two groups of models, it can be found that the standard deviation of BP neural network model is much larger than that of CPSGA-BP neural network. Especially in the fifth set of test data, the standard deviation of BP Neural network model is about 4 times of that of the standard layer of CPSGA-BP neural network model. Therefore, it can be considered that the CPSGA-BP neural network model is superior to the BP neural network model from the perspective of the stability of the model [7].

In conclusion, from the perspective of precision and stability of model, the CPSGA-BP neural network model is superior to the BP neural network model, which shows optimization of BP neural network model by the CPSGA algorithm is better.

6 Conclusion

Research on ecological logistics evaluation model based on BCPSGA-BP neural network, this paper combines environmental logistics, agile logistics, lean logistics, reverse logistics, environment-friendly logistics, recycle stream and so on. Through the construction of rural incubation base, the ecological logistics processing system is formed and a set of practical model is established to promote the development of rural logistics industry. While developing

Table 9 Comparison of stability between CPSGA-BP neural network and BP neural network

Test data	M1	M2	M3	M4	M5	Average relative error	Standard deviation	Standard deviation of CPSGA-BPmodel
1	7.33%	6.89%	5.53%	7.64%	8.36%	7.33%	0.009411	0.002297
2	9.04%	8.58%	7.27%	8.44%	7.49%	9.04%	0.006738	0.003064
3	6.37%	7.49%	8.26%	8.38%	8.35%	6.37%	0.007729	0.005548
4	6.46%	8.58%	6.97%	7.96%	6.99%	6.46%	0.007671	0.005928
5	10.64%	8.84%	7.72%	8.35%	7.84%	10.64%	0.010586	0.002626

ecological logistics, use R-commerce logistics platforms to reduce logistics costs, increase the trading volume of agricultural products, and increase farmers' income. Incubation base is a microcosm of the development of ecological logistics. The operation mechanism, scale and concept of incubation base have important guiding significance for modern logistics. In the process of incubation base construction, ecological technology and logistics industry are highly integrated to improve the ability of sustainable development of ecological logistics. On the other hand, establishing a set of effective index system and adopting scientific analysis methods are the necessary measures to construct the performance evaluation model based on BCPSGA-BP neural network of ecological logistics, and are the inherent requirements of promoting the ecological logistics in all enterprises as well.

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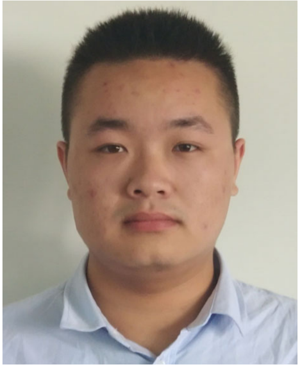
Weihui Du received the Master's degree and the Ph.D. degree from China University of Geosciences, Wuhan, Hubei province, China in 2007 and 2011 respectively. Her research interests include Management Information System and Cold Chain Logistics.

Xiaofen Zhou received the Bachelor's degree in management from Shangdong Technology and Business University, Yantai, Shangdong province, China in 2010. And received the Master's degree in Engineering from Wuhan University of Technology, Wuhan, Hubei province, China in 2013. She research interests include Purchasing and supply chain, Logistics system.



Changxiang Wang received the Bachelor's degree in management from Wuhan Technology and Business University, Wuhan, Hubei province, China in 2018. His research interests include e-commerce logistics, agricultural logistics, logistics information system and logistics operation model.

Donglin Rong received the Master's degree and the Ph.D. degree from China University of Geosciences, Wuhan, Hubei province, China in 2004 and 2017 respectively. His research interests include GIS and Land Space Planning and Utilization.