Research on Location Selection of Agricultural Products Logistics Distribution Center Based on Two-stage Combination Optimization Algorithm

Li Ma*
Sichuan Vocational and Technical College, Suining, Sichuan, China

*Corresponding author: ncmali@163.com

Abstract. The development of agricultural product logistics has a great impact on agricultural development. With the advancement of modern agriculture, agricultural product logistics is also facing important changes. On the basis of spatial analysis to determine the candidate address of the distribution center, this paper takes the lowest comprehensive cost as the objective function, establishes the distribution center location model, and solves it through the immune algorithm. On the basis of determining the distribution center, a distribution route optimization model with hard time windows for multiple distribution centers is established, and the tabu search method is used to solve the problem. According to the demand for time-sensitive fruit and vegetable agricultural products in a certain area and the actual circulation and distribution of fruit and vegetable agricultural products in newly developed enterprises, it is combined with the work done by the fruit and vegetable time-sensitive cold chain location planning model. Taking the grape distribution of Xinfadi Co., Ltd. in a certain area as an actual example of the model, using LINGO to solve and analyze the site selection model constructed in the paper, it verifies that the site selection plan for agricultural products that takes into account the characteristics of a complete cold chain and time-efficiency in this paper has a comprehensive low cost advantage.

Keywords: agricultural product logistics, location of distribution center, immune algorithm, taboo search

1. Introduction
Agricultural products are products that the country and people rely on for survival, and ensuring the safety of agricultural products is related to the overall situation of social stability and development. The vigorous development of modern logistics of agricultural products is of great significance for improving the efficiency of agricultural product distribution, reducing costs, effectively solving the "three rural" problems, improving farmers' lives, increasing agricultural production, and promoting rural prosperity [1]. The logistics cost of agricultural products is mainly generated during the distribution period [2]. The reasonable location and layout of agricultural product distribution centers can not only effectively improve logistics efficiency, reduce distribution costs, reduce loss rates, and reduce waste, but also optimize the entire supply chain system.
The distribution center is a circulation node that organizes distribution sales or supply and performs physical distribution as its main function [3]. It also has the intelligence of a collection center and a distribution center. As a result, the location of the distribution center must conform to the city plan and need good transportation resources, and systematic research should be carried out in the context of considering the regionalization and rationalization of commodity transportation and the forecast of the development demand of the distribution area [4]. So far, there have been many researches on the location of distribution centers at home and abroad, while the research on the location of cold chain logistics distribution centers is relatively small. The discrete location method first selects several suitable feasible location locations, usually called alternative distribution centers, calculates the objective function values of these feasible locations, and compares them to obtain the most optimal location location. Commonly used are linear programming, Baumol-Wolf method and so on. The Delphi site selection method starts from qualitative analysis and focuses on making judgments based on expert experience and professional knowledge, and transforming them into numerical values for comprehensive analysis and processing to determine the best site selection. The advantage of the Delphi method is that it can more comprehensively consider the influence of various factors, but this type of method may have empirical misjudgments that may lead to suboptimal site selection results. Fuzzy evaluation methods are commonly used. The distribution center is a circulation node that organizes distribution sales or supply and performs physical distribution as its main function. It also has the intelligence of a collection center and a distribution center. Therefore, the location of the distribution center must conform to the city plan and need good transportation resources, and systematic research should be carried out in consideration of the regionalization and rationalization of commodity transportation, and the forecast of the development demand of the distribution area [5]. The research on the location of cold chain logistics distribution centers is relatively small. Direct delivery is a "point-to-point" delivery from one supply point to one demand point. In this case, the demand at the demand point is usually close to or greater than the rated load of the available vehicle. In view of the characteristics of agricultural product hub and spoke logistics network and the timeliness requirements of agricultural product logistics, relevant scholars applied system reliability to the research of node location of agricultural product logistics network [6]. Under the premise of satisfying timeliness, an objective function for minimizing transportation costs is established to select the location of agricultural product logistics network nodes, and a hybrid leapfrog algorithm based on global collaborative search is designed to solve the model.

To solve the problem of route optimization, it is necessary to analyze the road network layer of the city and provide real road information data for the solution. To analyze the shortest path between nodes based on the road network layer, the actual road network entity must be abstracted into a network diagram in the network graph theory, and the shortest path of the road network must be realized through the network analysis theory in the graph theory analysis. Based on the actual calculation examples of Xinfadi Agricultural Products Company in a certain area, the LINGO model solving software is used to solve the model calculation examples. The solution and analysis results verify the feasibility and rationality of the paper's time-sensitive agricultural product cold chain location planning. Although the calculation of the example data in this paper is relatively simpler than the original model, it does not affect the comparative evaluation of the model constructed in this paper.

2. Two-stage Combinatorial Optimization Algorithm

2.1 Location Model of Distribution Center
The road network and facilities involved in the location of the agricultural product logistics distribution center can be abstracted into point, line, and surface spatial entities, and their spatial, temporal and thematic attributes can be expressed through spatial data and attribute data. Among them, spatial features mainly refer to geometric features such as the location, shape and size of spatial features, as well as the spatial relationship with neighboring features. This article refers to each supply point and demand point, as well as their related road topological relationships, etc.; attribute data
refers to the attribute characteristics of spatial phenomena or spatial objects. It refers to other characteristics of spatial phenomena other than time and space characteristics. This article refers to topography, land cover type, population density, traffic flow, etc.

Network analysis is the most important function when selecting the location of a distribution center. It is used to analyze the interrelationship and internal connection of each node in the logistics network, including path analysis, resource allocation, connectivity analysis, flow analysis, etc. Path analysis can find the best path from one node to another; resource allocation includes target site selection and finding demand markets or demand resource points for supply centers; connectivity analysis is used to solve problems related to distribution routing and reduce distribution cost; the problem of flow analysis is mainly based on a certain optimization standard such as the least time, the lowest cost, the shortest distance, or the largest transportation volume.

The location of the agricultural product logistics distribution center is still essentially a minimum cost issue. This article comprehensively considers the total transportation cost of the agricultural product logistics distribution system formed by the three main logistics nodes of agricultural product supply points, agricultural product logistics distribution centers, and agricultural product demand points, the fixed costs of agricultural product logistics distribution centers and the variable processing costs of agricultural products in and out of the center. Based on these factors, the location model of the agricultural product logistics distribution center is established.

The immune algorithm is proposed based on the recognition mechanism of foreign antigens in the immune system. The antigen corresponds to the objective function of the optimization problem, and the antibody corresponds to the solution of the optimization problem. You determine the binding power between antigen and antibody according to the objective function, and determine the binding power between antibodies according to the similarity of the solution. The two binding powers are used to evaluate and select the solution, and the mutual stimulation between the antibodies improves the best advantage. The search efficiency of the memory cell effectively gets rid of the local optimum through the inhibition of the antibody. The flow chart of the immune algorithm is shown in Figure 1.

2.2 Distribution Route Optimization Model
When the shortest path analysis operation is performed on the road network, the system can directly extract the network topology of the road network from the topology information table. The shortest distance between the distribution center and each customer and the shortest distance between each customer are saved in the database to provide data for solving the route optimization problem. When carrying out the optimization analysis of the distribution vehicle route in the newly created functional layer, the actual distribution network entity must also be abstracted into the network diagram in the network graph theory, and then the optimization analysis should be performed.

This article focuses on the characteristics of the large variety, small quantity, large batches,
complex traffic conditions, perishable deterioration, and relatively fixed sales period of agricultural products in the logistics distribution process of agricultural products, and implements the implementation of agricultural products from multiple distribution centers to multiple customers with multiple vehicles distribution.

The location of the distribution center, the location and demand of customers, the load capacity of each vehicle, the maximum driving distance of the vehicle at one time, and the agricultural products supplied by the distribution center can meet the needs of all customers. It is required to arrange the vehicle distribution route reasonably to minimize the distribution mileage. The logical structure diagram of the system integration is shown in Figure 2.

![System logical structure diagram](Image)

**Figure 2** System logical structure diagram

Tabu search algorithm is another optimization method to solve combinatorial optimization problems, and it is also a generalization of local search algorithm. This paper uses this algorithm to solve the optimization of agricultural product logistics distribution path.

Given a current solution (initial solution) and a kind of neighborhood, we determine several candidate solutions in the neighborhood of the current solution; if the target value corresponding to the best candidate solution is better than the "best so far" state, you ignore its taboo feature, use it to replace the current solution and the "best so far" state, and add the corresponding object to the taboo table, and at the same time modify the term of each object in the taboo table; if there is no such candidate solution, you select non-taboo in the candidate solution. The best state is the new current solution, ignoring the pros and cons of it and the current solution. At the same time, the corresponding object is added to the taboo table, and the tenure of each object in the taboo table is modified; the above iterative search process is repeated until the stopping criterion is met.

3. Empirical Analysis of Location Model of Agricultural Product Logistics Distribution Center

3.1 Analysis of the Supply and Demand of Fresh Fruits and Vegetables in a Certain Region

There are 16 districts and counties under the jurisdiction of a certain area, including Dongcheng, Xicheng, Chaoyang, Haidian and Fengtai. According to the population statistics at the end of last year, there were more than 21.148 million permanent residents in a certain area, of which the urban population reached 84.51%. In a certain region in 2018, the city's GDP reached 1,950.056 billion yuan, and the city's per capita consumption level was 31,350 yuan. The per capita disposable income of urban residents ranks ninth with 40,321 yuan. From a national perspective, it is a region with high per capita income and consumption levels, and has very high demand and price affordability for high-quality, time-sensitive agricultural products. Statistics show that while the consumption expenditure of fruits and vegetables by urban residents in a certain area has increased significantly, they are pursuing the development of green, healthy and balanced nutrition of fruits and vegetables.

The production areas of fresh fruits and vegetables in a certain area are relatively diversified, but the supply of fruits and vegetables in the north of the Yangtze River is the main source. In terms of supply quantity alone, the supply of fresh fruits and vegetables from Shandong and Hebei to a certain region accounts for half of the fresh fruit and vegetable market in a certain region, as shown in Figure
3. Vegetables and edible fungi  
Cold meat  
Aquatic products  
Fresh milk and dairy products  
Dried and fresh fruits  

Figure 3 The output of major time-sensitive agricultural products in a certain region in 2018

A certain area Xinfadi Agricultural Products Co., Ltd. is a large-scale agricultural product circulation and sales enterprise established based on the structure of a modern joint-stock company. The distribution and sales of fresh fruits and vegetables, chilled meat, aquatic products and other agricultural products are its current main business scope. Xinfadi and its subsidiaries, as a veritable large-scale fruit and vegetable distribution company in a certain area, provide more than 74% of the total demand for fresh vegetables in the capital every year, and at the same time undertake about 79% of the supply of fresh fruits in the city. About 88% of the mid-to-high-end imported fresh fruits in the region are mainly distributed and supplied.

In recent years, the company’s fruit and vegetable distribution and supply chain of time-sensitive agricultural products has been steadily extending to the production areas and sales terminals of agricultural products. While Xinfadi's business in a certain area extends to both ends of the supply chain and its business volume is steadily increasing, there is an urgent need to build a cold chain distribution center that is compatible with time-sensitive fruits and vegetables.

3.2 Site Selection for Cold Chain Distribution of Grapes in Xinfadi in a Certain Area

Using lingo11.0 to solve the calculation example by programming the known data, the model obtains the global optimal solution after 5813 iterations, that is, the optimal cost of the cold chain system is 9766801 yuan, and the selected alternative address is an alternative distribution center W2, alternative distribution center W4, and alternative distribution center W5. That is, every day distribution center W5 purchases 41 tons of grapes from Yanqing, Huailai transports 33.51 tons and 15.06 tons of grapes to alternate distribution centers W2 and W4 respectively, Changli transports 20.60 tons of grapes to alternate distribution center W5, and Weixian transports 50.11 tons to W4. The relevant distribution volume to the demand point can be seen in Figure 4.

Figure 4 Daily transportation quantity from agricultural production base to distribution center

Without considering the damage and cost of spoiled goods, the energy consumption of vehicle refrigeration, and the customer's requirements for circulation time, the above calculation example is
calculated again. After programming and 2877 iterations, the best alternative address is W1, W4, the total cost is 1,177,700 yuan, which is far greater than the comprehensive cost of the time-sensitive agricultural product cold chain considering the cooling energy consumption and the cost of spoiled goods. This has caused the overall uneconomic phenomenon of time-sensitive agricultural product cold chain operations. Moreover, the solution results increase the time for time-sensitive agricultural products in the circulation and distribution process, and reduce the corresponding degree of customer demand and customer satisfaction. This has not yet considered the additional pressure on urban traffic and the environment.

4. Conclusion
With the goal of the lowest overall operating cost, a location model for distribution centers that meets the actual operation of agricultural products is proposed. According to the characteristics of the model, this paper proposes an immune algorithm to solve it. The theoretical analysis and the results of the location selection of the distribution center show that the immune algorithm is not only effective but also feasible, and it solves the degradation problem in the genetic algorithm. We use LINGO programming model solving software to program and solve time-sensitive and non-time-sensitive models. Through the solution results, a relatively optimized alternative location of the distribution center is obtained and compared with the solution results. The constructed time-sensitive cold chain distribution center location model has relatively comprehensive cost advantages and is more comprehensive. It is necessary to further study and improve the model in the future to further improve the accuracy of the model. With the expansion of the model scale, higher requirements are inevitably placed on the efficiency of the algorithm, so it is necessary to carry out research on the application of new intelligent algorithms.

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References
[1] Mihajlović, J., Rajković, P., Petrović, G., et al. The Selection of the Logistics Distribution Center Location Based on MCDM Methodology in Southern and Eastern Region in Serbia. Operational Research in Engineering Sciences: Theory and Applications, vol.2, no. 2, pp. 72-85, 2019.
[2] Chen, L., Ma, M., Sun, L. Heuristic Swarm Intelligent Optimization Algorithm for Path Planning of Agricultural Product Logistics Distribution. Journal of Intelligent & Fuzzy Systems, vol.37, no. 4, pp. 4697-4703, 2019.
[3] Li, J. Optimal Design of Transportation Distance in Logistics Supply Chain Model Based on Data Mining Algorithm. Cluster Computing, vol.22, no. 2, pp. 3943-3952, 2019.
[4] Cui, X., Liu, J., Tian, Y., et al. GIS-Supported Airfield Selection Near Zhongshan Station, East Antarctica, Based on Multi Sensing Data. Marine Geodesy, vol.42, no. 5, pp. 422-446, 2019.
[5] Karakuş, C. B., Demiroğlu, D., Çoban, A., et al. Evaluation of GIS-based Multi-criteria Decision-making Methods for Sanitary Landfill Site Selection: the Case of Sivas City, Turkey. Journal of Material Cycles and Waste Management, vol.22, no. 1, pp. 254-272, 2020.
[6] Zupko, R. Life Cycle Assessment of the Production of Gasoline and Diesel From Forest Residues Using Integrated Hydrolysis and Hydroconversion. The International Journal of Life Cycle Assessment, vol.24, no. 10, pp. 1793-1804, 2019.