Acta Technica *62* (2017), No. 4A, 739–744

Emergency supplies demand forecasting for large scale natural disasters

Li Chunru[2]

Abstract. Categories, degrees and possibilities of natural disasters vary greatly in different areas and different seasons, so the types and amount for emergency supplies are also different. Generally, emergency supplies demand can be forecast through the establishment of model. From the perspective of early warning management, historical and geographical distribution of natural disasters can be analyzed by applying ARCGIS to make spatial statistics, and establish composite demand distribution model of multi-disaster emergency supplies with certain defense levels, in order to solve the problems according to disasters distribution design application examples in China, and provide support for emergency supplies reserve decision.

Key words. Natural disasters,emergency supplies,demand forecasting.

1. Introduction

The accuracy of the demand forecasting of emergency supplies in large-scale natural disaster areas will directly affect the quality and efficiency of disaster relief, so on the emergency supplies demand forecasting, we should make use of ARCGIS to forecast the emergency supplies demand on the basis of early warning management. Taking the actual situation of the disaster area into consideration, we should first establish a disaster case base in our country according to the historical data, and then determine the key factors influencing the emergency supplies, and finally establish the emergency supplies demand forecasting system model and fulfill the forecasting goal.

[1]Acknowledgement-This paper is a periodical achievement of the research topic "Study on the Strategy of Emergency Supplies Reserve for Large Scale Emergencies", supported by Philosophy and Social Science Foundation of Jiangsu Provincial Universities (research number: 2015SJB721).

[2]Workshop 1 - Huaian Vocational College of Information Technology, Huai'an, Jiangsu, 223003, China

2. Theoretical Analysis of Emergency Supplies in China

2.1. Research Ideas

The main task of this project is to complete the large-scale natural disaster emergency supplies demand forecast with the methods of system analysis, model, algorithm and application research on the basis of modern research. Thus the latest research results and trends can be learnt and the quality of the research can be improved. In the prediction of supplies demands, it's necessary to construct the mathematical model and implement the demand forecasting with the research results of reserve distribution decision theory and the current practical investigation of the domestic and international emergency supplies reserve as the basis. ARCGIS spatial statistics are used to do the demand forecasting. After the establishment of the model, it is necessary to carry out the actual data validation or computer simulation through fuzzy clustering algorithm. Finally, a numerical example analysis is made to study the current situation of emergency supplies demand and to put forward the corresponding countermeasures [1, 2].

2.2. Theories of Emergency Supplies Demand

There are many types of natural disasters in China. The ARCGIS space statistics show that the common natural disasters include not only the sudden disasters such as earthquakes, volcano eruptions, tsunamis, typhoons, landslides and floods, but also the environmental pollution disasters, such as drought, desertification, gradual drought and water pollution. These disasters pose a great threat to the safety of human's life and property. After natural disasters, it's critical to do emergency supplies allocation and supplies preparation. Different scholars define the emergency supplies from different angles and scopes. Taking the current definitions and literature research into consideration, the author defines the emergency supplies as: the indemnificatory supplies used to cope with large-scale natural disasters or public safety emergency. When we forecast the emergency supplies demand of the disaster area, it is necessary to consider the types, quantity, quality and structure of emergency supplies. We should take many factors into consideration and predict the emergency supplies demand according to different classifications and levels of the demand[3].

3. Model Building and Analysis

3.1. Establishment of Weight Coefficients[3]

Supposing that there are z cases, and case set with m attributes in the database, attribute set F=[F F F..... F], $\omega = [\omega_1 \cdots, \omega_m]$ on the above basis, the influence weight set meets the conditions$\sum_{j=1}^{m} \omega_j = 1$, in which j=[1,2,3..... m].

Data case set is used to construct the attribute value matrix D. Target case isD^0, D= [D D D..... D]. Matrix D and target case Dtogether form matrix$\Omega_{(z+1)\times m}$.

The entropy weighting method is used to normalize the matrix as D, which is normalized as G, and the standard deviation of matrix G with relatively small differences is obtained.

Formula 1: $D_{ij}^{*} = \frac{L+D_{ij}^{*}}{\sum_{i=1}^{n}(L+D_{ij}^{*})}$, in which i=1,2,3. . . . . z, j=1,2,3. . . . . m

Standard matrix G is as follows:

Formula 2: $G^{ij} = \frac{L+D_{ij}^{*}}{\sum_{i=1}^{n}(L+D_{ij}^{*})}$, L=2.

Taking formula 1 into 2, we can get the j normalized index expectation$\mu_j = \frac{1}{z}\sum_{i=1}^{z} G_{ij}^{*}$, standard deviation$\sigma_j = \sqrt{\frac{1}{z}\cdot\sum_{i=1}^{z}(G_{ij}^{*}-\mu_j)^2}$, and according to$\sigma_j$, the j index weight $w^j$of case base is calculated: $w^j = \frac{\sigma_j}{\sum_{j=1}^{m}\sigma_j}$.

3.2. Fuzzy Clustering Algorithm

Fuzzy clustering algorithm is proposed to solve this problem. It proposes the overall plan and takes urgency, importance, interchangeability, access difficulty, timeliness, raising cycle and raising cost into consideration, which helps to forecast the demand of emergency supplies according to different classifications and levels [4, 5].

Fuzzy C clustering algorithm in fact divides 1 vector xinto c category groups, x=[x x. . . . . x], q ranges between 1, 2, 3, ... l; When the classification is completed, clustering center of each category group will be calculate to have the minimum objective function value of non-similarity index, in order to reduce the impact on emergency supplies demand.

Clustering algorithm will be used to do fuzzy division, to make the membership degree of each element in the range of 0˜1, if the membership degree of a data set is 1, then $\sum_{i=1}^{c}\mu_{ij} = 1,\ j = 1, 2, 3, \cdots, l.$

In the formula,μ_{ij} represents the membership degree of the data set, and the value is in the range of 0˜1; c_i is the clustering center of category group I; d_{ij} represents the distance between the j data point and the i clustering center, which can be simplified as$(c_i\ x_j)$; the range of value m??fuzzy weighted index??is$[1, +\infty)$.

3.3. Determination of Key Factors

In order to construct the prediction model, it is necessary to learn the most basic key factors and determine the similar cases by using the key factors, which will help to carry on the scientific reasonable prediction for the supplies demand, [6].

To complete the demand classification prediction of emergency supplies after disaster, firstly the relationship between demand and variables, such as disaster categories, disaster mild, disaster season, and the number of victims. A conceptual model is set up based on the relationship between the requirements variables. The specific formula is$\Gamma = f(\alpha, \beta, \delta, \varphi, \gamma)$, in which$\Gamma$represents supplies demand, and the extreme is the ultimate goal of emergency supplies demand forecasting. α represents the types of disasters; β represents the disaster intensity;δrepresents the types of supplies; φ represents disaster season or time, γ represents the number of people affected by the disasters, including the people whose property are lost and whose lives are threatened, such as the homeless, the injured, the dead and so on.

Supposing a large earthquake occurs in a region, and the earthquake brings great harm, and the death toll and property loss degree are very high, we can make Qian Xinming's study on the demand for emergency supplies per capita [7] as one of the basic standards of emergency supplies demand forecasting, and predict the demand of emergency supplies by the calculation methods of the following supplies.

First of all, it is necessary to make clear of the basic data range of the variables such as$\alpha, \beta, \delta, \varphi, \gamma$and other variables in the disaster area. The data can be got by drawing lessons from the emergency supplies demand in similar historical cases, and taking the actual situation of the local disaster into consideration. Thus the demand for emergency supplies in this region can be roughly determined.

The general calculation formula for the real supplies demand of the similar historical cases (large-scale, high grade seismic earthquake) is as follows:

Number of the tents=0.25×the number of the homeless, which mainly refers to the affected people without any relatives or friends who can accommodate them; number of the stretchers =0.08×the number of the injured; number of the medical drugs =2.5×the number of the injured; volume of plasmml=50×the number of the injured. The calculation data are based on the number of the original stretchers, and the actual demand can be obtained by reducing the original amount with the calculation data.

General prediction for dietary needs: cooked emergency food (kg) =0.5×total number of people in disaster areas; instant emergency noodles (packs) =2×total number of people in disaster areas; emergency drinking water (kg) =2×total number of people in disaster areas.

General prediction for accommodation: number of quilts / blankets =0.02×total number of people in disaster areas; cotton / clothing pieces=6.8×the number of the injured+2.156×total number of people in disaster areas; shoes pairs=0.79×the number of the injured +0.2×total number of people in disaster areas. Total number of people in disaster areas includes total number of victims and total number of rescue people. When calculating the amount of clothing, and the number of quilts, etc., we need to reduce the original amount and number. This prediction method is a general demand prediction based on the similar cases.

Similar cases are determined based on the analysis, and demand for emergency resources are attained by modeling. Supposing there are q kinds of supplies demand, emergency supplies demand index of similar cases is r, the total amount of supplies demand is φ, and key index value of the target case is R, we can obtain h type supplies demand φ of the target case according to the similar principle.

$\varphi^{T-h} = R^T \cdot \frac{\varphi_h}{r}$, in which h is in the range of 1,2,3. . . . . q

According to the constructed demand model, the final demand forecasting formula is:

$$\varphi^{T-mean} = (\frac{\varphi_1}{r_1} + \frac{\varphi_2}{r_2} + \cdots + \frac{\varphi_n}{r_n}) \cdot R^T$$

Taking φinto φ, we can get the final actual demand amount based on the understanding of the differences of key clustering supplies and key factors.

4. Countermeasure Suggestions

(1)Grading and Classification of Emergency Supplies Demand

Fuzzy clustering analysis is made to classify and grade the emergency supplies demand and to judge and predict the actual demand of emergency supplies according to the usage classification, the specific circumstances and nature of supplies demand. Emergency supplies are used to achieve the first aid and satisfy the victims' requirements of clothing, food, housing, and other basic requirements. In the light of the nature of emergency supplies and the relationship between goods and supplies, the emergency supplies of natural disasters are divided into 4 categories .

(2)Grading of Emergency Supplies Demand

According to the essential characteristics of emergency supplies and the relationship between species, multi-objective optimization and cluster analysis are applied to establish a comprehensive model of emergency supplies classification, so as to complete the hierarchical demand forecasting of emergency supplies. The main purpose of classification management of emergency supplies is to determine the level of emergency supplies demand, which can optimize the quality of demand forecasting, better complete the procurement, storage and transportation of goods, and facilitate the rapid allocation and management of the limited emergency resources.

(3)Constant Improvement of Emergency Supplies Reserves Security Mechanism in China

In recent years, natural disasters frequently occur in China. In order to reduce the threats that natural disasters bring to people's life and property, the government should continue to improve our emergency supplies security mechanism, increase the cohesion of reserves, distribution, and transportation of emergency supplies, and ensure emergency supplies be delivered to the disaster area fast and efficiently.

5. Conclusion

Spatial statistical methods of geographical information system should be fully utilized for the large-scale natural disaster emergency supplies demand forecast. With the similar historical case data as the base of the demand forecasting model, we can grade and classify the emergency supplies demands based on the emergency resource distribution data. Generally, fuzzy clustering analysis and fuzzy comprehensive evaluation are used to carry out classification research. Through the construction of conceptual model, a comprehensive index system is established to comprehensively reflect the level of emergency supplies demand. Due to the sudden and non-routine natural disasters, in the real supplies reserve, the dynamic multi-objective decision model of maximum utility and maximum degree of time satisfaction should be established, which can solve the problems of supplies objects distribution, agreements and reserves of production capacity. Level of distribution and interchangeability of supplies is comprehensively considered to carry out fuzzy clustering analysis and better forecast the demand of emergency supplies.

References

[1] Sui. Kai, Wang. Yuhan, Wang. Shaoyong, Chen. Changzhi, Su. Xingrui: *Power Grid Emergency Supplies Demand Prediction Method Based on Multiple Regression Analysis.* Electronic Technology and Software Engineering *23* (2016), 195–197.

[2] Zeng. Bo, Meng. Wei, Liu. Sifeng, Li . Chuan, Cui. Jie.: *Grey Heterogeneous Data Forecasting Modeling Method for Disaster Emergency Supplies Demand* .China Management Science *8* (2015), 84–91.

[3] Wang. Lanying, Guo. Zixue,Zhang. Yufen, Shang. Yongsheng, Zhang. Lu: *Emergency Supplies Demand Forecasting Model Based on Intuitionistic Fuzzy Case-based Reasoning.*Journal of China University of Mining and Technology *4* (2015),775–780.

[4] Wang. Tongyuan: *Emergency Rescue Supplies Demand Forecasting Methods Summary of Major Natural Disasters.*China Merchants *17* (2015),105–105.

[5] Sun. Qinying: *Fault-tolerant Planning for Emergency Preparation of Large-scale Natural Disasters.* Harbin Institute of Technology (2016).

[6] Deng. Yongwei: *Allocation System Construction Study on Emergency Supplies for Natural Disasters Based on the Model of Situation—-Response.*University of Electronic Science and Technology of China(2016).

[7] Duan. Zaipeng, Qian. Xinming, Xia. Dengyou: *Dual Search Prediction of Emergency Supplies Demand Based on FCM and CBR-GRA.* Journal of Northeastern University (NATURAL SCIENCE EDITION) *37* (2016), 756–760.

Received November 16, 2016