The Construction of Orange Drought Warning Model

——A Case Study of Beibei Orangery in Chongqing City

ZHOU Shuang-yan*, **ZHENG Xun-gang**

College of Economics and Management, Sichuan Agricultural University, Ya'an 625014, China

Abstract On the basis of expounding the status quo of China's orange drought warning model research, according to the real-time monitoring data of Beibei Orangery in Chongqing City from June to August in 2010, by using factor analysis and principal component regression, we construct the drought warning model of Beibei Orangery in Chongqing City, and we conduct test and correction on drought warning model by using MAPE principle of assessment and prediction accuracy and the real-time monitoring data of September. The results show that as for the prediction of orange drought, the model has strong credibility. If we conduct continuous dynamic monitoring on the relevant indices regarding orange drought by virtue of this model, and pay attention to the analysis of variation trend of prediction value, then it will be more practical; the warning effect, to some extent, further indicates that using factor analysis and principal component analysis method to conduct drought warning is rational; as the prediction model is static and linear, so we should perfect model to promote the accuracy and practicality of model.

Key words Orange, Drought warning, Chongqing City, Principal component analysis method, Factor analysis method, China

Currently, orange is the fruit in China with biggest output in the world, and is also the second biggest agricultural product of trading. Chongqing is the main production area of orange planned by agricultural ministry of China, with powerful industrial developmental foundation and matching technological popularization system, which has preliminarily formed complete industrial developmental chain. In 2005, the planting area of orange in whole city reached 253 hm^2, and the output of orange reached 1.06 million tons, accounting for 70% of the total output of fruits in whole city, which made orange become the first biggest fruit. The orange industry is the dominant industry in agricultural economy of Chongqing and the source of farmers' wealth.

Along with the increasingly warm global climate, impact of El nino phenomenon of Pacific Ocean and the lagged response of southern region climate to El nino phenomenon, the weather of drought easily happens in southwestern regions, resulting in agricultural drought, socio-economic drought and so on. Chongqing, located in subtropical zone and China's western regions, has uneven precipitation distribution and high frequency of drought, so drought has become the main obstacle to growing and cultivation of fruit trees and crops in this region. Due to the covertness and long period of drought, it is important to conduct effective monitoring on drought. Warning, as an effective way of monitoring drought, has achieved good application results in some countries around the world. The so-called warning is to monitor change of hydrology and weather factors, and state of water source and water use in the target region, by selecting a group of corresponding drought warning indices; identify every phase of drought development at early stage; release the drought warning information timely for the relevant departments of government, various kinds of social institutions and public by many kinds of approaches, in order to make good reparation in advance and attain the goal of mitigating the drought losses to the extreme.

So, researching the establishment of drought warning model of orange and developing drought warning design system have great significance to knowing the degree and distribution of drought timely, adopting effective measures of drought prevention, ensuring water balance of demand and supply, promoting healthy development of orange and developing modern orange industry.

1 The status quo of research on drought warning model of orange in China

At the present time, most of the researches concerning warning model are on financial risk of listed company or medium-small-size enterprises, then on pest disaster and natural disaster, such as snow disaster and drought disaster, and finally on the credit risk of commercial bank and risk warning model of enterprise trust. In addition, there is a handful of researches on warning model of financial crisis, sales risk of enterprise, food security and so on. The main research methods are artificial neuralnetwork method, main component analytical method, logistic regression analytical method, Bayes classification method, support-vector machines and so on. The main research accomplishments are as follows: Dang Zhenglei(2008) used the financial index data of listed companies in China and factor analysis as well as Logistic Regression and other methods to construct logistic model of financial risk warning, and used the annual data to test the accuracy of model and to predict that the accuracy will reach 94.6%[1]; Pei Yu and Tang Wenbin (2007) used the data of successive three years regarding three companies of the same trading and main component analytical method to construct the warning model of financial risk of the three companies, and then analyzed the status quo of financial risk of the three companies based on these[2]; Luo Youxi (2005) adopted kernel function to construct model by

Received: January 13, 2011 Accepted: March 20, 2011
* Corresponding author. E-mail: Zsy_20042354@163.com

using main component analytical method to simplify model-construction indices, and demonstrated that the function of indices of this model excels traditional test method which can better solve the problems of large-scale sample set application[3]; Cao Zhiyong (2010) constructed warning model pest disease of plant on the basis of Particle Swarm Algorithm and neural network algorithm by the research on relevant rationale and method of warning model of pest disease of plant, coupled with coefficient optimization of neural network by using Particle Swarm Algorithm, and the results show that the construction of this warning model is feasible[4]; Wu Renye (2009) used harmonic analysis method to conduct mathematical simulation on the data regarding daily mean value of minimum air temperature (TDX) of every quarter of December from 1961 to 2006 in Zhangzhou City, got the variation law of low temperature of every quarter in December in Zhangzhou City, constructed three warning models applicable to variation trend of TDX of every quarter in December in Zhangzhou City based on these, and the prediction results show that there will be no low temperature disaster on fruit trees in Zhangzhou City in 2009[5]; according to the characteristics of spring snowmelt flood in northern Xinjiang and the status quo of local socio-economy, Yan Yan (2009) divided the main factors impacting the degree of spring snowmelt flood disaster in Xinjiang into four types of factors, namely nature, economy, population and contribution of flood-prevention facilities, further refined the four types of factors, quantify them as corresponding indices, then constructed warning index model of measuring spring snowmelt flood on the basis of these indices, used the data about flood disaster historically in Juntang Lake valley in Hutubi County to test the warning index model and achieved good results[6]; Yuan Weigen (2010) used the factor analysis method to construct emergency warning index system of college students, and concluded that security administration problems can cause contingency of college students, and learning management problems was most unlikely to cause contingency of college students by analyzing all factors[7]; Zhang Debin (2010) used the data of practical food security and monitoring as sample, researched food security warning method based on BP neural network, and conducted training and test by using the data and sample; the results showed that the food security warning method based on BP neural network can identify effectively and remember the characteristics of food danger, and can conduct effective prediction on samples[8].

Along with the development of computer technology and network popularization, software technology and network technology gradually are blended into the field of drought monitoring and warning. Many scholars researched the drought warning model. The main research results are as follows: on the basis of former drought remote sensing monitoring model by using cumulus coefficient method, Liu Liangmin (2009) conducted spatial-temporal correction on cumulus coefficient, established the new drought remote sensing monitoring model by using cumulus coefficient method with spatial-temporal universality, which made the results of drought monitoring in different regions in different periods more convincible[9]; according to the field experimental data from 2002 to 2005 and observed data of soil moisture of farmland from 1990 to 2005, Qi Huan (2009) analyzed drought level of winter wheat and summer corn in Huaibei of Anhui Province and appropriate soil moisture, established 36 medium-term precipitation forecast models quarter by quarter based on regular weather data, established 24 soil moisture regression models year by year based on temperature, precipitation and other weather factors, established agricultural drought forecast mathematical model quarter by quarter based on soil moisture balance equation, established agricultural drought overall warning model in Huaibei based on integration of all models, developed drought warning and irrigation decision-making computer service system of winter wheat and summer corn based on results of drought and precipitation forecast, appropriate moisture index of crop-soil, critical period and key period of needed water amount of crops and critical value of soil moisture and its service effects are outstanding[10]; Yang Yongsheng (2007) introduced soil water content indices to determine drought indices, such as capillary burst water content and perishing water content, which can judge drought degree of crops according to the practical situation of agricultural production, established drought monitoring and warning model according to soil moisture balance theory, conducted judgment and analysis on drought situation by using weather data and precipitation trend forecast, and adopted Surfer software to conduct direct visual show on drought situation[11]; Sun Xiubang (2007), in terms of weather factors relevant with relative moisture of soil, conducted drought warning model of 3 climate zones in the north Yangtze River of Anhui Province by using gradual regression analytical method and analyzing the relationship between relative moisture and weather factors in drought periods from 1990 to 2001, and the application of typical drought period indicated that all models can be applied to practical drought warning[12]. In the process of development and application of drought warning system of orange, Zhong County of Chongqing is the vanguard in China. In June, 2006, Zhong County of Chongqing established Ba Mount monitoring center of orange informatization management system, which made fruit growers easily know the soil water content of orchard, moisture and temperature of fruit leaves so as to realize warning of high temperature and frost disaster and so on, and conduct fertilizing water management. At the present time, the Ba Mount monitoring center conducts the real-time monitoring on ecological information of orange and local weather in different altitudes of monitoring points according to the growing characteristics of orange in Ba Mount Town. The ecological information includes temperate and moisture of leaves, stalk water content and soil water content; the environmental information includes air temperature, moisture, wind speed, wind direction, radiation, precipitation and other key parameters. By collecting information parameters in due time, we conduct remote share, management and monitoring, and realize frost disaster forecast, warning of high temperature and drought, and remote management, intelligent decision-making and automatic control of fertilizing water system.

Based on the foregoing, the researches on drought warning model in China is relatively late, and at the present time, there are relatively many researches, while the research on drought warning model of orange is still at initial stage. The thesis takes the real-time monitoring data from June to August in 2010 in Beibei orangery of Chongqing as samples, constructs drought warning model of orange by factor analysis and regression analysis, tests and corrects the warning model by using MAPE evaluation and prediction accuracy standard and real-time monitoring data in September so as to make the model more precise and reliable.

2 The empirical analysis of drought warning model orange

2.1 Data source, research method and index selection

2.1.1 Data source. The research data are from drought prediction data in September and real-time monitoring drought data provided by Bebei Orange Research Institution of Chongqing. The data collection system adopted by this research, at regular intervals, collects the relevant parameters regarding leave water content from orange experimental base timely, and input these parameters in background server database by sensor. These real-time, reliable and precise data are preserved over the years.

2.1.2 Research method. The research use factor analysis and main regression to realize construction of Chongqing Beibei orange drought warning model. It also realized the factor analysis and main component regression under SPSS software environment.

2.1.3 Index selection. The research indices are from Beibei Orange Research Institution of Chongqing, and the detailed definition is seen in Table 1.

Table 1 Definition of variables

Variable	Index	Variable	Index
y_1	Soil water content//%	x_{14}	Indoor dew point
y_2	Leave water content//%	x_{15}	Indoor heat index
x_1	Outdoor temperature	x_{16}	Indoor EMC
x_2	Outdoor moisture	x_{17}	Indoor air density
x_3	Dew point	x_{18}	Canopy temperature
x_4	Cold moisture	x_{19}	Canopy moisture
x_5	Heat index	x_{20}	Evaporation amount
x_6	Solar radiation	x_{21}	Soil sensor (10 cm) moisture
x_7	Solar energy	x_{22}	Soil sensor (20 cm) moisture
x_8	Maximum sunlight	x_{23}	Soil sensor (40 cm) moisture
x_9	UV	x_{24}	Soil sensor (60 cm) moisture
x_{10}	UV dosage	x_{25}	Soil sensor (10 cm) temperature
x_{11}	Maximum UV index	x_{26}	Soil sensor (20 cm) temperature
x_{12}	Indoor temperature	x_{27}	Soil sensor (40 cm) temperature
x_{13}	Indoor moisture	x_{28}	Soil sensor (60 cm) temperature

3 Results and analysis

3.1 Factor analysis We use spass software and factor analysis method to conduct original data, so as to get eigen value, contribution rate, cumulative contribution rate and factor matrix (Table 1, 2, 3).

Table 2 Eigen value, contribution rate and cumulative contribution rate

Component	Eigen value	Contribution rate//%	Cumulative contribution rate//%
F_1	17.33	61.88	61.88
F_2	4.94	17.64	79.52
F_3	2.78	9.91	89.43
F_4	0.89	3.19	92.61
F_5	0.52	1.86	94.48
F_6	0.43	1.52	96.00
F_7	0.30	1.08	97.08
F_8	0.21	0.74	97.82
F_9	0.16	0.57	98.39
F_{10}	0.12	0.42	98.81
F_{11}	0.10	0.34	99.15
F_{12}	0.08	0.28	99.43
F_{13}	0.05	0.17	99.60
F_{14}	0.04	0.13	99.74
F_{15}	0.03	0.09	99.83
F_{16}	0.02	0.06	99.89
F_{17}	0.01	0.03	99.92
F_{18}	0.01	0.03	99.94
F_{19}	0.01	0.02	99.96
F_{20}	0	0.01	99.98
F_{21}	0	0.01	99.99
F_{22}	0	0.01	99.99
F_{23}	0	0	100
F_{24}	0	0	100
F_{25}	0	0	100
F_{26}	0	0	100
F_{27}	0	0	100
F_{28}	0	0	100

Table 3 Factor matrix (after orthogonal rotation)

Index	F_1	F_2	F_3	Index	F_1	F_2	F_3
X_1	0.62	0.71	0.24	X_{15}	0.58	0.70	−0.17
X_2	−0.78	−0.32	−0.34	X_{16}	−0.37	−0.45	−0.78
X_3	0.2	0.93	−0.01	X_{17}	−0.62	−0.76	−0.02
X_4	0.62	0.71	0.24	X_{18}	0.46	0.54	0.48
X_5	0.49	0.82	0.19	X_{19}	−0.66	−0.42	−0.38
X_6	0.93	0.31	0.12	X_{20}	0.91	0.37	0.15
X_7	0.93	0.31	0.12	X_{21}	−0.03	0.40	0.70
X_8	0.88	0.15	0.16	X_{22}	0.12	−0.05	0.97
X_9	0.93	0.22	0.09	X_{23}	0.12	−0.13	0.95
X_{10}	0.93	0.22	0.09	X_{24}	0.1	−0.17	0.92
X_{11}	0.88	0.13	0.14	X_{25}	0.41	0.86	0.11
X_{12}	0.65	0.70	0.23	X_{26}	0.14	0.86	0.39
X_{13}	−0.33	−0.40	−0.82	X_{27}	0.08	0.69	0.61
X_{14}	0.65	0.68	−0.26	X_{28}	0.1	0.52	0.75

We know that by establishing 3 main components, we can reach 89.43% accumulative contribution with 0.57% factor loss, so it meet the general contribution rate more than 85%. So this research extracts 3 main factors. From Table 3, we know that after orthogonal rotation, the impact of all indices on main component becomes very prominent. In order to highlight focus and explain effectively problems, we stipulate the threshold of absolute coefficient as 0.8, namely delete the variables whose absolute coefficient below 0.8, so we can get:

$F_1 = 0.93x_6 + 0.93x_7 + 0.88x_8 + 0.93x_9 + 0.93x_{10} + 0.88x_{11} + 0.91x_{20}$

$F_2 = 0.93x_3 + 0.82x_5 + 0.86x_{25} + 0.86x_{26}$

$F_3 = -0.82x_{13} + 0.97x_{22} + 0.95x_{23} + 0.92x_{24}$

3.2 Regression of main component After factor analysis, we can conduct regression analysis on principal component. The steps of principal component regression are as follows:

Firstly, we take F_1, F_2, F_p as independent variables and y as dependent variables so as to establish linear model:

$y = a_0 + a_1F_1 + a_2F_2 + \cdots + a_pF_p$

Secondly, we conduct OLS regression on model, delete insignificant independent variables after T test (namely insignificant principal component F), and continue to repeat step 1 and step 2 until all principal components pass T test.

Thirdly, the regression equation is gotten as follows:

$y = a_0 + \beta_1F_1 + \beta_2F_2 + \cdots + \beta_pF_p$

By spss 17, we can get the following result:

$\hat{y} = 19.485 - 0.027F_3$

(45.86) (−4.87)

In the bracket, it is T test value, the goodness of fit of regression $R^2 = 0.506$, F test value is 22.745, auto-regression test $DW = 1.783$. This regression, on the whole, fit linear model. There is no auto-regression. The impact of F_3 on y_1 is significant at level 0.05. The regression is simplified as follows:

$\hat{y} = 19.485 - 0.027(-0.82x_{13} + 0.97x_{22} + 0.95x_{23} + 0.92x_{24})$

$= 19.485 + 0.022x_{13} - 0.026x_{22} - 0.025x_{23} - 0.024x_{24}$

We use gradual regression to establish linear relationship between y_2, and F_1, F_2 and F_3 as follows:

$\hat{y} = 71.882 - 0.058F_2 - 0.007F_3$

(44.021) (−3.929) (−2.27)

As for regression fit, goodness of fit of regression $R^2 = 0.528$, F test value is 12.583, auto-regression test $DW = 1.715$. This regression, on the whole, fit linear model. There is no auto-regression. The impact of F_2 and F_3 on y_2 is significant at level 0.05. The regression is simplified as follows:

$\hat{y} = 71.882 - 0.058(0.93x_3 + 0.82x_5 + 0.86x_{25} + 0.86x_{26}) - 0.007(-0.82x_{13} + 0.97x_{22} + 0.95x_{23} + 0.92x_{24})$

$= 71.882 - 0.053x_3 - 0.047x_5 - 0.025x_{23} - 0.049x_{25} - 0.049x_{26} + 0.0057x_{13} - 0.0067x_{22} - 0.0066x_{23} - 0.0064x_{24}$

In the formula, x_{13}, x_{22} and x_{24} are key factors to y_1; x_3, x_5, x_{23}, x_{25}, x_{26}, x_{13}, x_{22}, x_{23} and x_{24} are key factors to y_2.

3.3 Model test and error correction When conducting prediction and warning, in order to make it become more reliable, we use MAPE prediction and warning accuracy test maxim (Martin & Witt, 1989) to test results of prediction and warning, and the formula is as follows:

$$MAPE = \frac{1}{M}\sum_{i=1}^{M}\left|\frac{\hat{y}_i - y_i}{y_i} \times 100\right|$$

In the formula, M is index of prediction and warning; $\hat{y}$ is the prediction value of index y. The standard of judgment can be seen as follows. In the test of MAPE prediction and warning accuracy, in the $MAPE$ value interval (0, 10), the accuracy type is excellent accuracy; in the interval [10, 20), the accuracy type is good general accuracy; in the interval [20, 50), the accuracy type is good general accuracy; in the interval [50,), the accuracy type is good accuracy.

If the value of $MAPE$ is bigger than 50, then we conduct correction on prediction model, and correction process is as follows:

(1) Add test value of independent variables, and delete or correct rationally odd value of independent variables;

(2) Conduct principal component regression on independent variables that are corrected so as to get new prediction model;

(3) Test MAPE, if $MAPE > 50$, then change linear model as non-linear model, such as polynomial model and so on, until $MAPE < 50$, passing test.

We put value of all indices in equation $\hat{y}_1$ and $\hat{y}_2$, and calculate $MAPE$, to get $MAPE$ value of 12.1. The accuracy soil and leaves water content of type is good accuracy. $\hat{y}'_s$ MAPE value is 1.9, and the accuracy type is excellent accuracy. We can use equation $\hat{y}_1$ and $\hat{y}_2$ to predict Beibei Orange in Chongqing.

When predicting Beibei Orange in Chongqing, the model framework is established as follows:

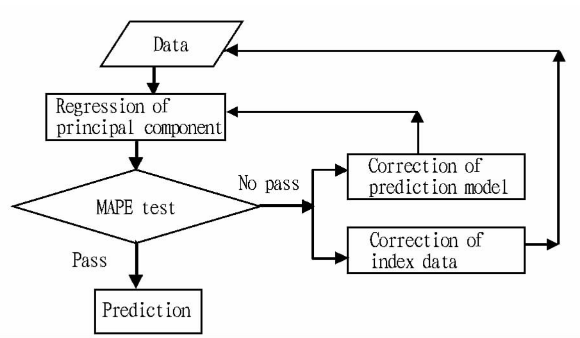

Fig. 1 The process of Beibei orange prediction in Chongqing City

When conducting model prediction, due to multifarious influencing index variables concerning soil water content and orange leave water content, we can use main component regression to get main influencing factors, so as to focus on main influencing variables and mitigate workload.

From research, we know that indoor moisture, soil sensor (20 cm) moisture and soil sensor (60 cm) moisture are key factor to soil water content; dew point, heat index, indoor temperature, soil sensor (40 cm) moisture, soil sensor (10 cm) moisture, soil sensor (20 cm) moisture, soil sensor (20 cm) temperature and soil sensor (60 cm) moisture are key factors to orange leave water content.

4 Conclusion and discussion

In terms of drought prediction of orange, this model has strong reliability; if we use this model to conduct continuous dynamic monitoring on relevant indices of orange drought and pay attention to analyzing the developmental change trend of prediction value, then it will be more practical. The forgoing warning effect, to some extent, further explain the reasonability of drought warning by using factor analysis and main component

(To page 145)

large market risks. Although theoretically and practically the transferring of surplus labors is the basis of agricultural development, chances brought by the transferring at least have not been transformed to be practical to the development of agriculture at present and face a lot of difficulties, such as weakened impetus of agricultural management, lowered efficiency in agricultural resources usage, weakened creation ability of farmers, assimilation of agricultural regions and obvious domination of oil agriculture and so on. In order to change these phenomena, it is necessary to reform the technical conditions, the property structures and the organization forms of agricultural management and to realize industrialization and modernization of agriculture. And all kinds of beneficial policies by government are also needed. So during the production processes of previous, producing and after in terms of agricultural production, communication, sales, consumption and services, there will have many potential profiting chances being realized.

Besides these, with the strengthening of urbanization and operation of the state rural policies, rural images, life styles of peasants, styles of actions, thoughts and consumption must be changed. All of which calls for punctuate supplying of public rural infrastructure, new-type rural education, medical insurance, technical and information equipments. Housing, household appliances and leisure services are also required. There will also appear a series of potential profiting chances among fields of rural publicity and private equipments. At the same time, the rapid urbanization of Henan and the transmission of southeastern industries would create more needs.

4 Conclusions

The economic supplying mechanisms do not devoid of other supplying mechanisms in rural construction. The research discusses the feasibility of the mechanisms and possibility to activate this kind of mechanism. A sustainable way in developing agriculture is to transform the functions of blood transfusion to functions of hematopoiesis formed by the premier transfusion. Of course, this is a task for current government.

References

[1] LU FY. On economic elite groups in the rise of social transformation in rural areas[J]. Journal of Zhejiang Normal University, 1998(5): 54 –59. (in Chinese).

[2] PENG GR. Foster pioneers to develop rural economy: survey and analysis of current experts on rural economy and research on their further education(I)[J]. Journal of Youjiang Teachers College for Nationalities Guangxi, 2004, 17(4): 32 –44. (in Chinese).

[3] HUANG ZJ, HU JZ. Economic analysis on the success of rural economic elite groups[J]. Journal of Anhui Agricultural Sciences, 2008 (5): 2093 –2094. (in Chinese).

[4] GAO F. The new pattern farmers are the real subject in the construction of new countryside[J]. The World of Survey and Research, 2007(4): 5 –7. (in Chinese).

[5] FU GZ, WEI ZY, HUANG RG. Rural economic elite groups and rural development[J]. Chinese Rural Economy, 2007(3): 38 –37. (in Chinese).

[6] PAN CG, LOU W. Intelligence return in rural China[J]. Chinese Journal of Population Science, 2003(5): 60 –65. (in Chinese).

[7] LI XJ, SHI HN. The empirical analysis on "energy" spread behavior of returnees in their hometown based on molecule transition reaction a case study of returnees in Gushi County in Henan Province[J]. Human Geography, 2009, 24(3): 5 –10. (in Chinese).

[8] HAN J, CUI CY. The boom of migrant workers return home for business is on the rise[J]. Rural Finance Research, 2008(5): 6 –8. (in Chinese).

(From page 140)

analytical method. In practice, if there are enough data, we can also this model to predict drought situation of orange and other crops in other regions. But there are shortcomings in the research as follows: firstly, the established model basically is stationary, and if we use this model to conduct continuous dynamic monitoring on relevant indices of orange drought and pay attention to analyzing the developmental change trend of prediction value, then it will be more practical; the research adopts linear model, but doesn't use time sequence model, non-linear polynomial model, logarithm model. By constructing non-linear model, we can promote prediction accuracy.

References

[1] DANG ZL. The early-warning model of the listed company finance crisis according to the logistic regressive[J]. Economic Research Guide, 2008, 25(6): 92 –95. (in Chinese).

[2] PEI Y, TANG WB. Building the enterprise financial risk model by using principal component analysis method[J]. Friends of Accounting, 2007, 4(1): 24 –26. (in Chinese).

[3] LUO YX, LIU XL, QIU ZY. Research on the combination and identification of financial crisis—based on kernel fisher method of principal component analysis[J]. Statistics and Decision, 2005(16): 31 –33. (in Chinese).

[4] CAO ZY, QIU J, CAO ZJ, *et al*. Construction of the early-warning model for plant diseases based on improving neural network[J]. Journal of Anhui Agricultural Sciences, 2010, 38(1): 538 –540. (in Chinese).

[5] WU RY, CHEN JH, XU ZH, *et al*. Early warning model of low temperature for fruit trees in december in Zhangzhou City and its application [J]. Chinese Journal of Agrometeorology, 2009, 30(4): 619 –624. (in Chinese).

[6] YAN Y, LIU ZH, YE CX. Establishment and validation of early-warning model for snowmelt flood in North Xinjiang[J]. Arid Land Geography, 2009, 32(4): 552 –557. (in Chinese).

[7] YUAN WG. Building early warning indicator systems of university students' emergencies by using factor analysis method[J]. Cards World, 2010(9): 267 –269. (in Chinese).

[8] ZHANG DB, XU JP, XU JJ, *et al*. Model for food safety warning based on inspection data and BP neural network[J]. Transactions of the Chinese Society of Agricultural Engineering, 2010, 26(1): 221 – 226. (in Chinese).

[9] LIU LM, XIANG DX, WEN XF, *et al*. Improvement of cloud parameters based drought monitoring model using remote sensing data[J]. Geomatics and Information Science of Wuhan University, 2009, 34(2): 207 –209. (in Chinese).

[10] QI H, ZHU YW, WANG DY, *et al*. Studies on drought forecast model and irrigation service systems in Huaibei areas[J]. Chinese Journal of Agrometeorology, 2009, 30(4): 596 –600. (in Chinese).

[11] YANG YS. Study on drought monitoring and early warning in Northern Guangdong[J]. Arid Environmental Monitoring, 2007, 21(2): 79 – 82. (in Chinese).

[12] SUN XB, YAN P, MA XQ, *et al*. Research on drought forecasting in north of the Yangtze River in Anhui[J]. Journal of Anhui Agricultural Sciences, 2007, 35(33): 10578 –10580. (in Chinese).