Changing Trend and Sustainable Development of Farmland Resources in Pingdingshan City, China

YANG Jin-wei*, LI Jian-min

Department of Mathematics and Information, Pingdingshan University, Pingdingshan 467000, China

Abstract The grey forecast and the sustainable use evaluation are conducted on the data of farmland resources from 2010 to 2020 in Pingingshan City by using the area of farmland land from 1999 to 2010 and by applying the grey forecast and land pressure system. The results show that from 2010 to 2020 the quantity of farmland resources maintains balance; the minimum per capita farmland in Pingdinshan stays around the lower limit of per capita amount of farmland in China; the pressure of farmland is rather huge and the farmland protection is not so optimistic. Therefore, in order to realize the sustainable use of land resources in Pingdinshan City, the government should try to improve the efficiency of farmland use and implement stricter land protection system. as well as the requisition-compensation balance of farmland resources, land consolidation and land reclaimation and so on.

Key words Farmland in Pingdingshan, City, Grey forecast, Minimum area of farmland, Land pressure, Sustainable development, China

Land is the most precious natural resources for human and the most basic material basis for the existence and development of human. With large population and scanty land resource, China faces the problems of coordinating the high speed development of economy, the rapid expansion of cities and the scantiness of land resources. These problems have become the key problems that need to be solved for the sustainable development of social economy.

The protection and control of farmland resources are the major importance in the reasonable use of land resources and the core of land planning and decision-making. According to statistics[1], from 1996 to 2005, the per capita area of farmland in Pingdingshan City has decreased from 0.07 hm^2 in 1996 to 0.064 hm^2 in 2005. The figures are lower than the 0.08 hm^2 of the per capita area in the whole province and 0.096 hm^2 of the per capita area of the whole nation, so the conflicts between population and land become more and more serious as the same period. As the national important production and processing base for the energy and materials and the chemical and industrial city in central China, the industrialization and urbanization of Pingdingshan demands more land, so the scantiness of land has increasingly become the choke point for the agricultural production and the sustainable development of national economy. In the paper, we mainly research the land resources in Pingdingshan City based on the data source of land resource from the *Statistical Yearbook of Pingdingshan City* from the year of 1998 to 2009. By combining the natural and social economy development situation, the mathematic mode is established and the land resources and its sustainable use degree in a certain future period of time are forecasted and evaluated.

1 Data source and research method

1.1 Data source The data are mainly from the *Statistical Yearbook of Pingdingshan City* from 1999 to 2010 (Table 1).

Table 1 The area of the farmland in Pingdingshan City from 1998 to 2009 $\times 10^3$ hm^2

Year	Area	Year	Area
1998	268.08	2004	315.42
1999	2 680.90	2005	315.40
2000	304.57	2006	312.91
2001	313.59	2007	312.91
2002	313.49	2008	312.89
2003	312.92	2009	312.89

1.2 Research method

1.2.1 Grey prediction. The grey prediction means using the GM(1,1) mode to predict the changing trend and the changing pattern of the features of the systematic behaviors[2]. The feature of grey prediction is that its the single sequence prediction. In formality, it only establishes the time series mode for the prediction subject, and the relevant factors do not involve in the computation and mode establishment.

The system of the changing trend of farmland resources is grey and is affected by many factors. Limited by the available data, the complex relations among the factors can not be determined. So the GM(1,1) grey prediction mode is applied to find useful information to establish mode from the time series of the changes of farmland resources , and then find and know the inner rules of the time series and predict it.

1.2.1.1 The testing and treatment of data. In order to ensure the feasibility of the way of establishing mode, the necessary testing and treatment of the available data should be conducted. Suppose the reference data are $x^{(0)} = [(x^{(0)}(1), x^{(0)}(2),$

Received: August 23, 2010 Accepted: October 25, 2010
Supported by the Key Projects of Science and Technology Plan of Henan Province (102102310299); The Research Fund for Youth in Pingdingshan University (2008046).
* Corresponding author. E-mail: youngjinwei@126.com

$\cdots, x^{(0)}(n)]$, then the step-ratio of the sequence of number can be calculated.

$$\lambda(t)=\frac{x^{(0)}(t-1)}{x^{(0)}(t)}, t=2,3,\cdots,n$$

If all the step ratio $\lambda(t)$ can be included in $X=(e^{\frac{-2}{n+1}}, e^{\frac{2}{n+1}})$, then the number sequence $x^{(0)}$ can be used as the GM(1,1) mode to conduct data grey prediction. Or else, the data $x^{(0)}$ should be exchanged to let it be included by the mode. That is to say, we should take a reasonable constant c to carry out the translation transformation.

$$y^{(0)}(t)=x^{(0)}(t)+c\ (t=1,2,\cdots,n)$$

Then the step ratio of the number sequence $y^{(0)}=[y^{(0)}(1), y^{(0)}(2),\cdots, y^{(0)}(n)]$

$$\lambda_y(t)=\frac{y^0(t-1)}{y^{(0)}(t)}\epsilon X(t=2,3,\cdots n)^{[2]}.$$

1.2.1.2 Establishing the GM(1,1) mode.

Step 1: conducting the accumulated generating processing on the original data ,that is;

$\chi^{(1)}=\chi^{(0)}(1)$,

$\chi^{(1)}(2)=\chi^{(0)}(1)+\chi^{(0)}(2)$,

$\chi^{(1)}(3)=\chi^{(0)}(1)+\chi^{(0)}(2)+\chi^{(0)}(3),\cdots,\chi^{(1)}(k)=\sum_{i=1}^{k}\chi^{(0)}(t)$, $\chi^{(1)}(M)=\sum_{i=1}^{M}\chi^{(0)}(t)$,

$\chi^{(1)}=[\chi^{(1)}(1),\chi^{(1)}(2),\cdots,\chi^{(1)}(M)]$.

Step 2: structuring the whitening differential equation, that is

$$\frac{dx^{(1)}}{dt}+ax^{(1)}=u$$

In the equation, a and u can be obtained by the following the least square method

$$\begin{pmatrix}a\\u\end{pmatrix}=(B^TB)^{-1}B^TY_M$$

In $Y_M=[\chi^{(0)}(2),\chi^{(0)}(3),\cdots,\chi^{(1)}(M)]^T$, B is the constructed data matrix

$$B=\begin{pmatrix}-\frac{1}{2}\chi^{(1)}(1)+\chi^{(1)}(2) & 1\\ -\frac{1}{2}\chi^{(1)}(1)+\chi^{(1)}(2) & 1\\ \vdots & \vdots\\ -\frac{1}{2}\chi^{(1)}(1)+\chi^{(1)}(2) & 1\end{pmatrix},$$

Then the time response function related to the differential equation is

$$\hat{\chi}^{(1)}(t+1)=[\chi^{(0)}(1)-\frac{u}{a}]e^{-at}+\frac{u}{a}$$

Step 3: calculating the grey prediction value[2]

$\hat{\chi}^{(0)}(t)=\hat{\chi}^{(1)}(t+1)-\hat{\chi}^{(1)}(t)$, $t=1,2,3,\cdots,n$.

1.2.2 The sustainable use degree of farmland resources. Based on the demands of regional food safety, the minimum per capita farmland area and the farmland pressure index in the evaluation index area which can be used to measure the sustainable use degree of the regional farmland resources are introduced into.

The regional minimum per capita farmland area[3] refers to the farmland area which can satisfy each person's normal need on food in a certain region and under the conditions of the self-sufficient level of foodstuffs and the comprehensive production capability. The minimum per capita farmland area provides the bottom line of the farmland that should be protected in a certain area for food safety, and it is of great significance in measuring the sustainable use degree of regional farmland resources.

The land stress index[3] refers to the ratio of the minimum per capita farmland area to the actual per capita farmland area. The land stress index not only tells the stress of farmland resources in a certain region, but also provides the threshold for the farmland protection, so it can be used as the controlling range for farmland protection in the region.

According to the statistical yearbook and the prediction data of the farmland resources, the regional minimum farmland area and the farmland stress index can be further revised by combining the actual situation of Pingdingshan City, so as to describe the sustainable use degree of farmland resources in Pingdingshan City better and provide the suggestions of adjustment and controlling.

The regional minimum per capita farmland area[3] provides the bottom line of protecting the number of farmland for guaranteeing the food safety in a certain area. The regional minimum per capita farmland area ($S_{\min}$, unit: hm^2) is the function of many factors covering self-sufficiency rate of food, food consumption level and the comprehensive production capability of food[4], the calculation mode is as follows:

$$S_{\min}=\beta\frac{G_r}{P_{q\cdot k}}$$

In the formula, β is the self-sufficient rate of food(%), k is the reclamation index(%), P is the per unit yield of food (kg/hm^2), q is the rate of the sown acreage of food to the whole sown acreage(%), G_r is the per capita amount of food demand (kg/people · year).

Farmland stress index[5] (K) refers to the ratio of the minimum per capita farmland area to the actual per capita farmland area, that is

$$K=\frac{S_{\min}}{S_a}$$

In the formula, S_a is the actual per capita farmland area (hm^2/people).

The value of K in different space cross section reflects the stress level born by the farmland resources in the place and at the time. We can choose different countermeasures according to the value of K, to adjust the pressure borne by the farmland resources and to realize the sustainable use of farmland resources. When K equals 1, it will become the warning line of the controlling and management for the farmland use and protection. At this time, the farmland erosion must be prevented and the use of farmland should be reasonably directed in the condition of improving the material input and production capability ;when $K<1$, the actual per capita farmland area is bigger than the minimum per capita farmland area, which shows that the supply capability of the farmland is higher than the food consumption level. In this case, the government can convert some farmland to urbanization and industrialization use, or restructure the agricultural planting structure and return farmland to forest and grass to improve the ecological environment;when $K>1$, the actu-

ally existed farmland can not satisfy the demand of per capita need of farmland, the farmland bears great pressure[3].

2 Prediction and evaluation

2.1 The prediction of farmland resources in Pingdingshan City The number sequence of the farmland area in Pingdingshan City from 1998 to 2009 (unit: $\times 10^3$ hm^2) is $x^{(0)}$ = (268.08, 268.09, 304.57, 313.59, 313.49, 312.92, 315.42, 315.40, 312.91, 312.91, 312.89, 312.89); by calculating, the step ration of number sequence is $\lambda(t)$ = (1.00, 1.14, 1.03, 1.00, 1.00, 1.01, 1.00, 0.99, 1.00, 1.00, 1.00), all the number can be covered in X(0.86, 1.17), so the number sequence $x^{(0)}$ can be used as the GM(1,1) mode to conduct grey prediction.

The once accumulated generating number sequence is $\chi^{(1)}$ = (268.08, 536.17, 840.74, 1 154.33, 1 467.82, 1 780.74, 2 096.16, 2 411.56, 2 724.47, 3 037.38, 3 350.27, 3 663.16);

By using the least square method, $a = -0.007\ 4$, u = 294.296 1, then the time response function in step 2 is

$$\hat{\chi}^{(1)}(t+1) = 40\ 108.44e^{0.074t} - 39\ 840.36$$

According to the equation of the grey prediction value the grey prediction of the area of farmland in Pingdingshan City from 2010 to 2020 can be seen on Table 2 and the actual value and the predicted value of farmland area of Pingdingshan City from 1998 to 2009 can be seen on Fig. 1.

Table 2 The grey prediction value of farmland area in Pingdingshan City from 2010 to 2020 $\times 10^3$ hm^2

Year	Predicted value	Year	Predicted value
2010	324.94	2016	339.66
2011	327.35	2017	342.18
2012	329.77	2018	344.72
2013	332.22	2019	347.27
2014	334.68	2020	349.85
2015	337.16		

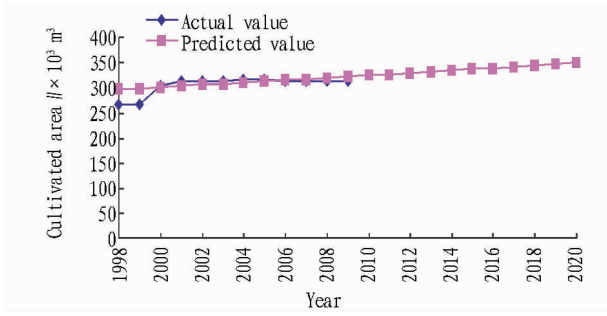

Fig. 1 The actual area and grey prediction value of farmland area in Pingdingshan City from 1998 to 2009

It can be seen from Fig. 1 that the predicted value and the actual value are nearly the same except for the value in1998 and 1999. The reason is that after 1999, the China carries out strict farmland protection policy, strengthens land consolidation and land reclamation, and the reclamation and compensation balance policies. So from 2000, the area of farmland increases obviously comparing with the former years. The testing of the predicted value shows that the prediction value is rather accurate.

2.2 The evaluation on the sustainable use degree of farmland resources Under the current production level, the sustainable use degree of farmland resources is calculated and evaluated according to the grey prediction value of the farmland resources in 2020. According to the population control index of the whole city, the population of the Pingdingshan City is assumed to be 5.7 million; the per capita food demand is assumed to be 386 kg/ftayear according to the reference data provided by the State Grain Administration; the reclamation index applies the 181.1% of 2009; the per unit yield of farmland and the proportion of food apply the 4 057.2 kg/hm^2 and 77.10% respectively, which is the average level of that of Pingdingshan City from 1998 to 2007 . thus the results of the calculation can be obtained, and they are shown on Table 2.

Table 3 The evaluation result of the sustainable use degree of farmland resources

Self-sufficiency rate // %	Reclamation index // %	Per unit area food yield kg/hm^2	Ratio of grain cultivated area to total agricultural crops cultivated area // %	Per capita food demand kg	Total population People	Predicted farmland hm^2	Regional minimum per capita farmland area // hm^2	Farmland pressure index
95	181.1	4 057.2	77.1	386	570	349 850	0.064 7	1.05
100	181.1	4 057.2	77.1	386	570	349 850	0.068 1	1.11
105	181.1	4 057.2	77.1	386	570	349 850	0.071 5	1.17

Under the current productivity and the food self-sufficiency rate of 95%, the minimum per capita farmland area is 0.064 74 hm^2 in 2020, a little more than the current per capita farmland (0.06 hm^2). If the food self-sufficiency rate is 100%, the minimum per capita farmland of Pingdingshan City in 2020 is 0.068 1 hm^2, higher than the bottom line of 0.067 hm^2, the average farmland area of our country, but far lower than the average level of 0.096 hm^2 of the per capita farmland area. The farmland stress index is bigger than 1, which indicates that under the current productivity , the stress of farmland is relatively large and the protection of farmland protection is not so optimistic, therefore, we must try to improve the use efficiency of farmland resources and implement stricter farmland protection system, at the same time, the land reclamation and compensation balance, land consolidation and land reclamation should be conducted well.

3 Conclusion

The sustainable development of Pingdingshan City can be attained, only by realizing the sustainable use of land resources and then the maximum of social, economic and environmental

(To page 41)

than the average increasing rate of peasants' income in the past years. Besides, the increasing rate shows the feature of gradually descending from fast to slow with weak sustainability.

Table 4 Data fitting and future forecasting

Year	2005	2006	2007	2008
Fitting value	1 478.5	1 635.2	1 923.1	2 102.7
Actual value	1 520.9	1 702.3	1 905.8	2 042.6
Year	2009	2010	2011	2012
Predicated value	2 282.4	2 502.9	2 686.9	2 884.5

Note: Unit is yuan, the unchanging price of 1992.

4 Conclusion and discussion

Under the dual influence of internal regulatory demand after the sustainable and high-speed growth of macro-economy and the external shock caused by global financial crisis, there will be more stress on the growth of peasants' income in the future. Not only the promoting effect of the price increase of agricultural products will abate, but room for political increase will be also limited. This suggests that there are still some profound systematic constraints to be broken through urgently, especially the city-biased economic policy implemented for many years by local governments. Otherwise, it would be difficult to substantially transform the social problem of " difficult to increase farmers' income" which has been puzzling Henan Province and even the country[11].

To settle the problem of peasants' income growth, the strategic thought should be proposed from a higher level and with broader horizon. An all-round and fundamental revolution in economic and social system should be conducted thoroughly at the macro level of the country. Moreover, the actual provincial conditions and characteristics of Henan as a major province in population as well as agriculture and the core area of grain of national strategic project should be considered and integrated so as to establish and perfect matching systems and carry out pertinent political measures, such as implementing the strategy of " two regurgitation-feedings" , establishing and perfecting rural social security system, constructing the transfer payment system aiming at the equalization of public service and setting up and perfecting rural organizational system of finance as well as agricultural insurance system and so on.

References

[1] YANG M. A research of the prediction model for Henan farmers' income growth with ARIMA measurement technique [J]. Economic Survey, 2007(4):110 -112. (in Chinese).

[2] ZHANG J, LIU XM, HE YL, *et al*. Application of ARIMA model in forecasting traffic accidents [J]. Journal of Beijing University of Technology, 2007(12):1295 -1299. (in Chinese).

[3] CLEMENTS MP, HAN DR, LU MZ. Forecasting economic time series [M]. Beijing: Peking University Press, 2008. (in Chinese).

[4] EN DS. Applied econometric time series [M]. Translated by DU J, XIE ZC. Beijing: Higher Education Press, 2006. (in Chinese).

[5] LUTKEPOHL H, KRATZIG M. Applied time series econometrics [M]. Translated by YI XJ, DENG KB. Beijing: China Machine Press, 2008. (in Chinese).

[6] FAN JQ, YAO QW. Nonlinear time series: modeling, prediction and application [M]. Beijing: Higher Education Press, 2005. (in Chinese).

[7] LI D, ZHAO Y. Rolling sample forecasting for Chinese international inbound tourism market—based on the ARIMA model with seasonal dummy variables [J]. On Economic Problems, 2008(6):124 -126. (in Chinese).

[8] LIU RL. Fluctuant cycle on income growth of peasants in Henan Province [J]. Journal of Sichuan College of Education, 2008(11): 37 -39. (in Chinese).

[9] Policy Research Office of Henan Province. Analysis on farmers' per capita net income in Henan Province [N]. Henan Daily, 2009 -03 -06(13). (in Chinese).

[10] ZHANG HC, CHEN HY. ARIMA forecast model of inbound tourism from Japan to China [J]. Journal of Jiangxi University of Finance and Economics, 2008(6):85 -88. (in Chinese).

[11] WANG H. China's economic growth and urban-rural income gap widens [J]. Shandong Economy, 2008(6):38 -42. (in Chinese).

[12] GUAN LL, MEN KP. Cluster analysis on per capita net income of rural households in China[J]. Asian Agricultural Research, 2009, 1(6):1 -3, 9.

[13] LEI L, XU JH, LIU DM. Investigation and analysis of the current situation of farmers' income in Yangling region[J]. Journal of Anhui Agricultural Sciences, 2007, 35(36): 12107 -12108. (in Chinese)

[14] GE F, HUANG J, MU YY. Comparative analysis on the effects of income structure on consumption level of rural residents in eastern and western China——a case study on Jiangsu and Xinjiang Province[J]. Asian Agriculture Research, 2009, 1(8):1 -5.

(From page 36)

interests can be realized. In order to realize the sustainable development of land resources of Pingdingshan City, the government should perfect the land management system; take the overall plan of land use as the basis; strictly manage the use of land; control the total construction land use; promote the intensive land supply of different land types and different function areas; establish strict land protection mechanism; implement the system of connecting the land protection with the interests and prices; promote the land reclamation and consolidate the industrialization of land; and carry out the land consolidation according to the local conditions and reasonably develop the land resources which have not been exploited yet[5].

References

[1] Land-use planning of Pingdingshan City (from 2006 to 2020) [EB/OL]. (2010 -05 -21) http://www. docin. com/P-43152680. html. (in Chinese).

[2] HAN ZG. Methods and applications of mathematical modeling [M]. 2nd ed. Beijing: Higher Education Press, 2009: 366 -378. (in Chinese).

[3] CAI YL, FU ZQ, DAI EF. The minimum area per capita of cultivated land and its implication for the optimization of land resource [J]. Acta Geographica Sinica, 2002, 57(2):127 -134. (in Chinese).

[4] CAI YM, ZHANG WX, LIU YS. Forecasting and analyzing the cultivated land demand based on multi-objectives in China [J]. Resources Science, 2007, 29(4):134 -138. (in Chinese).

[5] DENG YS, DENG LJ, ZHENG HW, *et al*. Analysis on assorted obstructs land utilization dynamic change and tendency forecasting in Shifang City [J]. Resource Development & Market, 2009, 25(1): 28 -30. (in Chinese).