Current Situations and Future Development Trend of Farmland Pre-warning Researches in China

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Abstract This paper summarized theory discussion, main research methods, contents, empirical and engineering researches of farmland pre-warning in China. It stated that future researches of farmland pre-warning in China will focus on deepening application of farmland security pre-warning models, revealing mechanism of changes in different farmland resources, establishing pre-warning models suitable for research areas, accurate evaluation and prediction of farmland security, and exploring establishing and improving farmland security monitoring system and operating mechanism of all levels.

Key words Farmland pre-warning, Security assessment and prediction, Research trend

1 Introduction

Land is the most important natural material base of agricultural production. At the present scientific and technological level, agricultural production is inseparable from land. Farmland, as a type of land resource, is the most important production element in grain production, and is the precondition for our survival. China's farmland is faced with problems of small per capita area, increasing reduction of total area, uneven distribution, low overall quality, and constant worsening of pollution. In particular, at the background of rapid industrialization and urbanization of China, farmland is still threatened by quantity, quality and ecological environment. This will inevitably influence China's grain security and national economic construction. Therefore, farmland issue has received close social attention. Now, researches are turning to strengthening awareness for unexpected development, security awareness, taking effective measures for protection and pre-warning of farmland, and promoting scientific and reasonable sustainable use of farmland. For China with 1.3 billion people, this is not a mere economic problem, but a problem concerning political stability, sound development of economy and society, and harmony of society.

Foreign scholars studied farmland pre-warning from different points of view. N. Goncharova *et al.*[3] analyzed regional land security from influence of agricultural pollution on land; Jeffrey *et al.*[4] analyzed land security from the perspective of influence of agricultural ecological environment changes on land; Haque C. Em-dad discussed danger of land resources from ecosystem material and energy flow-in and flow-out in the basin with Canada Red River as an example; JosePhine Philip discussed influence of farmland degradation from the perspective of land management system with Southern Africa as an example. Researches of Chinese scholars on land pre-warning started in the end of the 1990s. With introduction of foreign research achievements and increasingly prominent of China's farmland problem, the researches of land pre-warning take on rapid development trend. This study sorted out current situation of researches on China's farmland pre-warning from theoretical construction, method improvement, and research hotspot, and made basic judgment for future development trend.

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2 Current situations of researches on farmland pre-warning in China

2.1 Theoretical researches Most scholars extend connotation and research scope of farmland security from theories of grain security. Some scholars believed that farmland security means both quantity and quality of farmland resource and farmland ecosystem in a certain region can ensure sustainable, adequate and economic obtaining of food, and ensure survival and development of human in a healthy way[56]; they contended that researches of farmland security should be carried out from assessing whether farmland itself is safe, whether food supply of farmland is safe, and whether environmental impact of farmland use is safe[11]. Some scholars carried out empirical analysis on specific problems of farmland security from existing problems such as insufficient reserve resource, non-agricultural use of farmland, reduction of agricultural productivity, and ecological degradation of farmland resource in different regions of China[8-9, 57].

In researches of farmland pre-warning theories, Tao Junchang *et al.*[1] stated that farmland pre-warning is a type of farmland management activity using existing knowledge, technology and scientific method, on the basis of grasping and understanding development and change laws of farmland characteristics, analyzing existing status of farmland use, judging, describing and predicting trend of farmland changes, and making pre-warning using preset signals or in other manners, to predict abnormal time and space range or danger degree of farmland resources, so as to take pertinent preventive measures[1]. Liu Youzhao *et al.*[58] elaborated

basic contents of farmland pre-warning, including warning condition, warning source, warning sign, and warning level. Liu Yanfang[59] introduced farmland supply-demand dynamic balance pre-warning theory taking testing changes, finding warning condition, determining warning level, seeking warning source, screening warning conditions in the region and outer the region, from sign, action and results. Deng Yan *et al.*[2] present principles of farmland pre-warning: even if there is no sufficient scientific evidence to prove certain relation between a certain activity and its effect, as long as the activity may create some danger or hazard to farmland, it is required to use proper technologies or take pertinent measures to mitigate or eliminate such influence. In sum, domestic scholars have introduced concept of farmland pre-warning. With the deepening of researches, they put forward complete farmland pre-warning theory, and finally summed up principles of farmland pre-warning. These theories will have better guidance for future researches.

2.2 Major research methods Research methods of farmland pre-warning in China include application of single method and comprehensive application of multiple methods.

2.2.1 Application of single method. Scholars applied many kinds of single methods. Chang Sheng[45] calculated ecological footprint of farmland of Hubei Province in 2007 by ecological footprint method. Li Chunhua *et al.*[46] built an indicator system for evolution of farmland security system in Jiangsu Province and built quantitative evaluation model for evolution of farmland security system based on the information entropy theory. Cui Xufeng[39] studied farmland problem in hilly areas taking Shiyan City of Hubei Province as an example by field survey method. He Beibei *et al.*[32] introduced farmland quality conversion method and predicted farmland security trend of Anhui Province in 2020. Li Zhibin *et al.*[49] studied grain production security pre-warning based on GIS with three provinces in the northeast of China as examples. Tan Shukui *et al.*[50] built pressure system dynamics model for regional farmland using Vensim software, and predicted and simulated changes of farmland pressure index through simulation technology.

Besides, many scholars adopted mathematical statistics method, showing advantages of mathematical statistics method in researches of farmland security pre-warning. Ran Qinghong *et al.*[18] built expansion model of minimum per capita farmland area using linear regression equation and curvilinear equation. Lin Caixiong *et al.*[29] made a prediction analysis on farmland supply and demand with the aid of gray system GM (1, 1) model and unary regression analysis model. Xu Chuangxin *et al.*[48] made a quantitative analysis of the similarities and differences in humanistic driving power of farmland and construction land in Hubei Province with the aid of SPSS software. Wang Guoliang[31] revealed characteristics of changes in farmland resource in Shanxi Province by statistical analysis method. Pu Jinyong *et al.*[42], with the aid of mathematical statistical analysis method, analyzed characteristics of Tianshui City is population, farmland area, grain supply and demand, and farmland security in recent 30 years.

2.2.2 Comprehensive application of multiple methods. In recent years, some scholars applied two or three methods to study farmland. Qian Yurong *et al.*[47] combined BP artificial neural network and broad Monte Carlo method to make an in-depth analysis on the relationship between farmland, road, urban expansion, GDP and industrial economic structure using many years of data of TM remote sensing images, land use maps and yearbooks of Zhangjiagang City. Wang Yugang *et al.*[44] studied dynamic characteristics and development trend of salt in 0 – 20 cm soil in agricultural oasis of Xinjiang Sangong River basin by the combined method of remote sensing, GIS and statistics. These indicate the trend of combining modern geographical information processing technology and statistics methods.

2.3 Major research contents

2.3.1 Estimation of farmland red line. Du Zhongchao[21] estimated farmland red line per capita of 2010 and the middle of the 21st century for Shaanxi Province; Chen Baiming *et al.*[15], on the basis of 90% of grain self-sufficiency rate, determined the suitable farmland security baseline of China, and stated that all regions should formulate regional or provincial farmland security baseline criteria; Wang Nanjun *et al.*[27], taking Jiangsu Province as an example, made empirical research on estimation of provincial farmland security baseline; Ran Qinghong *et al.*[18] built an expansion model for minimum per capita farmland and determined the red line for China's per capita farmland and total farmland area of 2006.

2.3.2 Evaluation indicator system of farmland security level. Wu Wensheng *et al.*[12] put forward China's farmland security evaluation indicator system and criteria, and made evaluation and pre-warning of China's farmland security. Guan Yanbo *et al.*[30] set up the evaluation indicator system for farmland security of Shandong Province. Ge Xiangdong *et al.*[33] established farmland pre-warning indicator system for Wuxi City of Jiangsu Province on the basis of data of the Second Soil Census, many years of soil monitoring data, and statistical data related to farmland system status, in combination with survey and analysis of farmland situation in research areas. Tong Yiqin *et al.*[37] evaluated farmland security of Ningbo City using per capita farmland area, reserve of per capita farmland, farmland supplement coefficient and farmland quality. Li Chunhua *et al.*[46] built an indicator system for analyzing evolution of farmland security system of Jiangsu Province.

2.3.3 Prediction about future security level of farmland. Wang Junhou *et al.*[10] built a pre-warning model for overall level of regional land desertification and made a pre-warning for land desertification in 12 north provinces in China. Xiong Ying *et al.*[22] made prediction of future farmland resource and per capita farmland area of Hunan Province. Lin Caixiong *et al.*[29] made prediction analysis on farmland supply and demand of Hunan Province in the period of building a moderately prosperous society. Guan Yanbo *et al.*[30] expressed their opinions about farmland security level and status in Shandong Province over the next 10 years. He Beibei *et al.*[32] predicted farmland security trend of Anhui Province in

2020 from supply and demand of farmland security. Zheng Rongba *et al.*[38] predicted farmland security level and pre-warning level of Guangzhou Province in 2015 and 2020. Tan Shukui *et al.*[50] built regional farmland pressure system dynamics model and predicted farmland area, grain yield, farmland gap, and farmland pressure index of Hubei Province in 2000 – 2020 through simulation technology.

2.3.4 Countermeasures for farmland security. Hu Rong *et al.*[34] discussed farmland security of Chongqing Municipality, analyzed causes, and came up with recommendations, including adhering to family planning policy, strengthening propaganda and education, building farmland security system, and enhancing land market construction. Cai Yihui *et al.*[35] analyzed existing problems in farmland security of Zhangzhou City on the basis of statistical data of 1949 – 2003, discussed the formation mechanism, and came up with regulation countermeasures for farmland security. Lei Yun[36] studied farmland security of Liuyang City and put forward 5 countermeasures. Cui Xufeng[39] analyzed regional farmland security problem in special terrain areas taking Shiyan City as an example, and introduced some safeguarding measures. Hu Jian *et al.*[40], taking Baoding City as an example, studied building of farmland security mechanism in the process of urbanization, analyzed current situation of farmland in Baoding City, studied causes for reduction of farmland in Baoding City, and came up with specific measures for building farmland security mechanism in the process of urbanization.

2.3.5 Mechanism of changes in farmland security. Zhao Qiguo *et al.*[11] pointed out the inducing mechanism of China's farmland security, including population growth, social and economic development, land use ways and technological level, demands for environment optimization, and political factors. Feng Zhiming *et al.*[14] analyzed driving function of related farmland policies in different periods to changes in farmland area. Dong Limin *et al.*[17] discussed China's farmland security from agricultural natural disasters, ecological disasters, environment disasters and social disasters, and pointed out that the problem of farmland security and grain security is a policy and system problem to a great extent, and to solve the problem of sharp decrease of farmland and deterioration of quality, government act must be regulated firstly. Cai Yihui *et al.*[35] discussed the formation mechanism of farmland security in Zhangzhou City. Liu Zhongling *et al.*[43] analyzed complex and diversified structures and functions of ecological system in Heihe River basin, and discussed land resource and environment security in downstream area of Heihe River basin. Qian Yurong *et al.*[47] made an in-depth analysis on the relationship between farmland security and road, urban expansion, GDP and industrial economic structure of Zhangjiagang City. Xu Chuangxin *et al.*[48] made a quantitative analysis of the similarities and differences in humanistic driving power of farmland and construction land in Hubei Province. Tan Shukui *et al.*[50] established built regional farmland pressure system dynamics model and studied the relationship between factors influencing farmland security of Hubei Province.

2.3.6 Design and building of farmland pre-warning information system. Hu Baoqing *et al.*[51] built a stony desertification risk evaluation model with the aid of GIS technology, spatial statistical analysis and mathematical model. Xu Qirong *et al.*[52], taking Microsoft Visual Studio. NET 2003 as development platform, on the basis of soil environment quality standard, farmland irrigation water quality standard, and farmland ecological environment quality evaluation, made pre-warning for farmland ecological security in Anhui Province from soil fertility, environment quality, health quality, and output capacity, set up farmland ecological security pre-warning information system of Anhui Province, and expounded setting of pre-warning indicators and levels, and methods for realizing system functions. Li Zhibin *et al.*[53] stated that it is required to set up a GIS-based farmland pre-warning information system, namely, taking GIS as platform, integrating prediction model and expert system, and determining warning level through pre-warning model, to reach the dual pre-warning purposes, in the hope of providing a feasible and systematic scheme for regional farmland pre-warning. Zhang Honghui *et al.*[54-55], based on GIS technology and database technology, introduced overall flow of farmland quality pre-warning system, designed functions and database structure of the farmland quality pre-warning system, and established a complete set of farmland quality pre-warning information database and farmland quality pre-warning system with Jintan City of Jiangsu Province as an example.

2.3.7 Empirical studies. Since China is a large agricultural country with large population, satisfying food demand of people is always the basic content of China's agricultural security. As the most important and fundamental resource, farmland security inevitably becomes the key point of grain security. In line with these, domestic academic circle has carried out many aspects of empirical studies about farmland security and pre-warning.

At the national level, Wang Junhou *et al.*[10] built a pre-warning model for overall level of regional land desertification and made a pre-warning for land desertification in 12 north provinces in China, which provides certain reference for sand prevention and control project of China. Wu Wensheng *et al.*[12] put forward China's farmland security evaluation indicator system and criteria, and made evaluation and pre-warning of China's farmland security. Chen Baiming *et al.*[15] discussed grain self-sufficiency rate of China. The Information Center of Ministry of Land and Resources of China (ICMLR) made a comprehensive, scientific and in-depth analysis on China's farmland security in *Analysis and Report of Security of China's Land and Resources*. Li Zhibin *et al.*[49], based on national regional grain production security pre-warning model, made an empirical study on three provinces in the northeast of China with the aid of GIS.

At provincial, regional and city levels, many scholars have shown strong interest: Ni Shaoxiang *et al.*[20], Bian Jianmin *et al.*[13], and Du Zhongchao *et al.*[21] studied provincial or regional farmland security in Jiangsu, Jilin and Shaanxi provinces separately; Ge Xiangdong *et al.*[33], Hu Rong *et al.*[34], Cai Yihui *et*

al. [35], and Lei Yun *et al.* [36-38, 40-42] studied farmland security in Xishan, Chongqing, Zhangzhou, and Liuyang cities and countermeasures for farmland security.

At the basin level, Liu Zhongling *et al.* [43] studied land resource and environment security in downstream area of Heihe River basin; Wang Yugang *et al.* [44] studied salt changes in irrigated area and characteristics of farmland security with agricultural oasis in Sangong River as an example.

Empirical studies of China on farmland pre-warning are carried at national, provincial or regional, city-wide and basin-wide levels, of which the first three levels continue receiving more attention, while the last one receives little attention. With deepening of China's reform and opening-up and construction of market economy, some cities have problems of grain security, such as rapid growth of urban construction land area and excessive reduction of soil fertility, and then scholars start to pay attention to city-wide farmland pre-warning.

3 Development trend of researches on farmland pre-warning in China

3.1 Existing problems in researches on farmland pre-warning in China

3.1.1 Close attention to theoretical researches, but little attention to practice researches. Many China's scholars pay close attention to theoretical researches on farmland pre-warning using various mathematical models, evaluation procedure and methods, while few set up fixed and long-term experimental field (farm or station). This has a big gap with foreign researches.

3.1.2 Failure to establish universal standard of security pre-warning technical regulations. Mathematical models applied in various researches are varied, and they pay attention to different points. Besides, there is no universal security pre-warning technical regulation. As a result, various researches lack basis for horizontal comparison, and the reference significance of a farmland pre-warning evaluation model suitable for certain province or city is limited.

3.1.3 Farmland security pre-warning model being single and lacking mutual corroboration. Mathematical models used in farmland security pre-warning researches are single, lack comprehensive application and mutual corroboration of several models, lack inspection of model results, and actual guidance of model results needs strengthening.

3.2 Development trend of researches on farmland pre-warning in China

3.2.1 Researches on deepening application of farmland security pre-warning model. In future, farmland pre-warning researches at national, provincial, city and basin levels will pay more and more attention to actual guidance of prediction model on regional grain security, and pay more attention to application of models.

3.2.2 Researches on further strengthening mechanism of changes in farmland resource security at different levels. Core problems of farmland pre-warning researches lie in factors influencing changes in regional farmland security at different levels, and how these factors interact and influence regional farmland security. Scholars (for example, Tan Shukui *et al.* [50]) gradually strengthened researches in these areas, showing deepening of researches on factors influencing farmland security.

3.2.3 Researches on models suitable for research regions. Building a model suitable for research regions needs a process. Such process should follow the complex process of survey at the early stage – building model and database – test of model and database – application feedback of model and database – modification and improvement of model and database.

3.2.4 Researches on accurate evaluation and prediction of farmland security. With deepening of China's reform and opening-up and construction of market economy, people care more about grain quantity, quality, and ecological security, and people urgently need to know accurate prediction and evaluation of nationwide, province-wide, city-wide and basin-wide farmland security, to maximize management, production and living benefits of agricultural administration institutions, agricultural enterprises and institutions and residents in corresponding regions. Besides, scholars start to care more about raising accuracy in evaluation and prediction of farmland security.

3.2.5 Researches on exploring establishment and improvement of monitoring and operating mechanism for farmland resource security at all levels. In future, on the basis of "A whole Map" of remote sensing monitoring of national land and resources issued by Ministry of Land and Natural Resources and construction of the integrated supervision platform, it is recommended to management information including land use change survey, planning management, land use examination and approval, land consolidation, balance in requisition and compensation, and land law enforcement, to gradually realize comprehensive and dynamic supervision of farmland localization, quantitative determination, responsibility fixation, and supplement of prime farmland. At the same time of carrying out construction of farmland database, it is proposed to study information support system and application system for farmland pre-warning management at national, provincial, city and county levels. The *National Mid – and Long-term Plan for Science and Technology Development* (2006 – 2020) stated that it is required to develop "real-time soil, water, fertilizer, light and heat detection technology" and "agricultural and forestry ecosystem monitoring technology". The application of these technologies will provide real-time, accurate, rich and effective data support for building of farmland resource security pre-warning database, further benefiting farmland security pre-warning work.

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improve the recycling use of cemetery. In Taiwan, the cemetery is recycled every twelve years. By learning its experience, we can legally prescribe the years that a cemetery can be used, and strictly control the area of each cemetery, so as to promote the recycling. Third, by US laws, the area of cemetery is uniform. We can also learn from US and legally prescribe the area of each cemetery. Only in this way can the waste of cemetery lands be stopped.

4 Conclusion

The lands for cemetery is a special part of Chinese history and culture. Since a both economical and ecological cemetery has become the basic requirement for constructing a harmonious society, we should lay great emphasis on developing the multiple functions of cemetery lands according to the practical conditions in each area.

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