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Overview of Studies on Grain Security in China

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Abstract Through overview of relevant literature and on the basis of basically grasping frontier study and development trend, this paper discussed the grain security from industrial structure, farmland protection, grain import, urbanization and industrialization, grain reserve, ecological protection, and grain security pre-warning, in the hope of providing some convenience and reference for future related researches.

Key words Grain security, Farmland protection, Industrial structure, Grain subsidy

As a special type of commodity, grain is the basic food for human living and also the most important material base for survival and development of human beings. The grain security is always very important to the national economy and the people's livelihood and Chinese government always attaches great importance to grain security. The *Grain Security Report of China* stated that China's grain security basically features vulnerable balance, forced balance and tense balance. On November 29, 2013, the State Statistics Bureau issued an announcement stating that the total grain yield of China reached 601.935 million tons in 2013, having an increase of 2.1% on a year-on-year basis. Since 2004, China's grain yield has realized the 10th consecutive year of growth. However, except in 2008 and 2009, the grain yield was still lower than the demand, and the problem of "shortage of grain in bumper harvest year" is prominent. Thus, China's grain security is still very serious for a long period of time and it is very urgent to safeguard grain security. Central Economic Work Conference of 2013 stated that a national food security strategy based on domestic supply and moderate imports will be followed. It will ensure production capacity and endorse science and technology. It is required to ensure grain ration independently, and realize basic self-sufficiency of grain and absolute security of grain ration through concentrating domestic resources. Besides, it will lay more stress on quality of agricultural products and food security, transform mode of agricultural development, and do a good job in safeguarding grain security. These set forth overall arrangement for increasing integrated production capacity of grain, ensure self-sufficiency of grain, and guarantee grain security. Based on these, we intend to make an overview of typical research achievements in recent years from resources, policies, and industrial structure, in the hope of provide reference for future researches.

1 The relationship between resources and grain security

1.1 The relationship between farmland resource and grain security As the most fundamental material condition for agricultural production, the farmland resource includes farmland quantity and quality. At certain technological condition, change in farmland quantity will inevitably influence grain production and supply; farmland quality is the sum of farmland soil quality, farmland environment quality, farmland management quality and farmland economic quality, and its change will influence integrated production capacity and efficiency, and accordingly influence grain production and supply^[1]. Some scholars discussed the correlation between quantity and quality of farmland and grain security. Zeng Kejun *et al.* found that the grain yield is highly correlated to land use changes, changes in the effect of farmland quantity and quality on grain production and grain security sensitivity coefficient take on regular change in different periods, showing farmland quantity and quality are important factors restricting grain security^[2]. Fan Chengyong believed that there is significant correlation between farmland area and grain yield; keeping necessary farmland area is a basic condition for grain self-sufficiency and security of China, and reducing farmland pressure is the key for sustainable grain production^[3]. Zhang Guangsheng contended that total grain yield decreases with shrinkage of farmland and the decrease rate is higher than that of farmland area^[4]. Researches of Chen Ligen *et al.* indicated that urban construction only accounts for one tenth of the total reduction of farmland, while the reduction of grain yield resulted from urban construction accounts for more than one fourth of reduction of total grain yield, thus occupation of farmland for urban construction poses a big threat to China's grain security^[5]. Xu Shengxiang *et al.*, based on GIS technology, studied influence of farmland quality on grain security with Jiangling County of Hubei Province as an example. Jiangling County has high farmland production potential and comparative advantage in grain production, which has positive contribution to satisfying grain demand of Hubei Province and even the whole China^[6]. Zhu Hongbo found that farmland quantity and quality and ecological condition exert different influence on grain security and coordinate relationship between

farmland protection subjects^[7]. In the opinion of Wang Jing, at current stage, it is required to greatly improve farmland quality and grain production capacity, attach great importance to soil pollution, transform traditional grain supply idea, strengthen the effort of promoting agriculture through boosting industries, and changing the quantity oriented idea of balance in requisition and compensation, to realize both quantity and quality protection, and ensure all-round development of social economy^[8].

1.2 The relationship between water resource and grain security As fundamental resource of grain production, water directly concerns per unit area yield and total yield, and concerns stability and security of grain security. Nevertheless, the existing agricultural production mode in China is highly dependent on water; about 23% agricultural products are produced by irrigated farmland that accounts for 12% of farmland area, while the grain yield of irrigated farmland takes up about 75% of total grain yield^[9]. Some researchers have made corresponding studies on water resource and grain security from their perspective. Yuan Xianjiang believed that water plays a decisive role in grain production, and the fundamental solution to ensuring grain security lies in energetic development of water-saving irrigation and increasing utilization efficiency of irrigation water on the condition of limited farmland area, rapid population growth and insufficient water resource^[10]. Wu Kai introduced current development situation of China's farmland irrigation and irrigated grain crops, analyzed contribution of grain production in irrigation farmland to China's grain security, and found that irrigated farmland accounted for 43.8% of total farmland area and grain yield of irrigated farmland took up 75.9% of total grain yield in 2003^[11]. Wang Hao elaborated current situation of China's agricultural water and soil resources and their influence on grain production, comprehensively analyzed challenges faced by China's agricultural water and soil resources, introduced basic strategies for safeguarding China's agricultural water resource from "broadening resources of income and reducing expenditure", and present basic regulation direction of strengthening consumption management of soil and water resource^[12]. Wen Qun analyzed existing problems in China's grain security and sustainable development of water resource, and proposed feasible and operable measures to ensure grain security and sustainable development of water resource^[13]. Qin Dayong found that by 2010, Heihe River has potential of increasing 118.5 million hectare irrigated area, conservatively estimated grain yield up to 161.5 million tons, increasing about 17% of existing grain production capacity, solving basic grain demand for 550 000 people in surrounding poverty-stricken areas^[14]. Tang Libin contended that the contribution of water and soil conservation to grain security takes on rising trend, but the overall contribution rate is still low, especially in southwest. Therefore, it is required to reinforce water and soil conservation, to provide powerful safeguard for China's grain security and sustainable development^[15].

1.3 The relationship between climate resources and grain security Agriculture is based on crop growth, so it is greatly in-

fluenced by climate changes. Climate changes will directly lead to time and space changes of water and heat resources in major agricultural regions of China, lead to changes of soil fertility, crop varieties and their stress resistance, and directly result in increasing occurrence and intensity of agricultural climate disasters and plant diseases and insect pests in some areas. In the action of climate changes, China's agricultural crop planting system, agricultural production structure, and regional distribution will have corresponding changes, leading to fluctuation of grain yield, or even influence national grain security^[16]. Some scientific researchers have analyzed the relationship between climate changes and grain security. Ren Chunyan believed that global warming will result in drop of grain yield, and came up with specific measures for avoiding and mitigating influence of climate changes on grain security^[17]. Wu Bin found the close connection between grain supply and occurrence of natural disasters in central Shaanxi area in Zhou, Qin, Han and Tang dynasties^[18]. Wang Dan stated that since the reform and opening-up, the influence of climate changes is positive on China's grain production, contributes about 3% of increase of grain yield, which is mainly benefited from timely adjustment of rice distribution^[19]. Study of Zhou Shudong indicates that the drop of per unit area yield of grain resulted from temperature rise will exert certain unfavorable influence on future grain production in China^[20]. Chen Weihong stated that the area covered and affected by natural disasters has strong weakening function to grain yield, and reduces the integrated production capacity of grain, thus it is recommended to establish integrated domestic grain price system and supply-demand balance mechanism, reduce sensitivity of market response, raise grain farmers' enthusiasm, ensure sown area of grain crops, and increase subsidy for grain farmers to reduce losses from disasters^[21].

1.4 The relationship between biomass resources and grain security Biological fuel is a fuel that contains energy from geologically recent carbon fixation. These fuels are produced from living organisms. Examples of this carbon fixation occur in plants and microalgae. These fuels are made by a biomass conversion (biomass refers to recently living organisms, most often referring to plants or plant-derived materials)^[22]. This biomass can be converted to convenient energy containing substances in three different ways; thermal conversion, chemical conversion, and biochemical conversion. This biomass conversion can result in fuel in solid, liquid, or gas form. This new biomass can be used for biological fuel. Biological fuels have increased in popularity because of rising oil prices and the need for energy security. At present, the biological diesel and fuel ethanol are most common biological fuels. They take grain crops and oil crops as raw materials. This will significantly increase demands for grain raw materials and exert significant influence of China's grain production, trade and price^[23]. Some scholars in biological energy and grain security field have carried out related researches on influence of biological energy on grain security. Li Zhiqiang found that the development momentum of domestic biomass energy will exert pressure on grain production

and increase potential risk of grain security^[24]. Zhang Zhang *et al.* believed that it is possible to solve raw material problem through planting oil crops in waste farmland and reduce the pressure of biological fuels on environment and grain supply^[25]. Sun Fenglian concluded that rise of oil price and population has great influence on demands for corn, but brings about grain security problem only in certain condition^[26]. Wang Xiang thought that the influence of biomass energy development is varied on different grain crops, and it will pose a great threat to grain security of corn, soybean, and rape seed^[27]. In the opinion of Wang Fangwei, production of fuel ethanol using corn as raw material is restricted by land factor, it will exert certain influence on China's grain security, thus it is recommended to explore internal potential and seek substitute approach to promote development of fuel ethanol^[28].

2 The relationship between policies and grain security

2.1 The relationship between grain reserve and grain security

As the top strategic security of China, the grain security is always top priority of administering state affairs well and ensuring national security, and always the foundation for promoting economic development and keeping social stability. Grain reserve is stocks of grain held in reserve intentionally by government programs for the purpose of meeting future domestic and international needs. It is an extremely important part of national grain security system, the essential material base of national macro adjustment and control ability, and a strategic measure of a country or region to respond to natural calamities, emergencies, stabilize grain price, ensure grain supply, and maintain social stability^[29]. Some scholars studied the relationship between grain reserve and China's and regional grain security. On the basis of summarizing purpose, influence factors, and functions of China's grain reserve, Liu Lifeng analyzed changes of farmers' grain storage and the influence on national grain security since the grain reform in 2002, and stated that the decline of grain storage further intensifies pressure and risk of overall grain supply, increases risk of regional grain security, and increases financial burden of national grain security^[30]. Wei Xiuyan estimated that total grain supply and demand of China will keep relative balance in 2006–2030. On the basis of overall balance, China should have optimum grain reserve of 18.177 million tons, and have 44.245 million tons of extreme reserve capacity^[31]. In the opinion of Zhou Fusheng, central grain reserve should be kept in 30–35 million tons, and central grain reserve should focus on rice and wheat, and consider reasonable distribution and storage in production and sales regions^[32].

2.2 The relationship between grain security pre-warning and grain security

With regular characteristic of fluctuation in grain supply and demand as the starting point, on the basis of theory of grain production and supply–demand balance, the grain security pre-warning focuses on dynamic monitoring and warning of grain supply and demand situations. It is helpful for grasping national and regional grain supply and demand situation and making

prediction about possible problems, to provide scientific and rapid decision-making tool for the national grain macro–control authorities^[33]. Some agricultural experts have analyzed and discussed the influence of grain security pre-warning on grain security. Wang Xuezheng believed that the grain security is a complicated system, so it is difficult to measure with a single indicator and it is required to establish a complete national grain security pre-warning system incorporating grain production fluctuation index, grain reserve level, degree of dependence upon foreign trade, and actual disposable income per capita^[34]. Zhao Caiyan established grain security pre-warning indicator system with total regional grain supply and demand as indicator of warning conditions, made empirical analysis of grain security pre-warning with Xuzhou City as an example, and concluded that grain security pre-warning condition of Xuzhou City in 2010 would be slight shortage^[35]. Xiao Guoan *et al.* introduced a new, more scientific and simple grain security pre-warning model "dynamic pre-warning model" on the basis of discussing pre-warning of grain yield growth rate, grain supply–demand pre-warning model, grain security factor pre-warning model, grain periodic fluctuation pre-warning model, and prosperity analysis pre-warning model and grain security integrated pre-warning model^[36–42]. Xiao Shunwu discussed three core problems for improving China's grain security pre-warning mechanism, namely organization structure, information collection, and information transmission^[43]. Li Mengjue, from realities of grain production in Hunan Province, using related theories of pre-warning, studied monitoring pre-warning of grain production, built grain production pre-warning system of Hunan Province, and made extrapolation pre-warning of grain production in Hunan Province^[44].

2.3 The relationship between grain trade, finance and grain security

Grain trade and grain financial policies will influence grain supply and demand and China's grain import and export to a certain extent, lead to fluctuation of grain price, and influence China's grain security strategy. Some experts of international economic trade and agricultural economics have given out corresponding introduction. The study of Zhang Jixiang indicated that reasonably adjusting grain import and export is an important approach for balancing domestic grain supply and demand^[45]. Sun Baomin believed that China's grain security must set foot on domestic production, bring into full play domestic grain production capacity to realize grain self-sufficiency, moderately import grain to make up for gap of domestic demand, give play to comparative advantage, and expand export trade^[46]. Song Liangwei *et al.* stated that China's grain security should not totally rely on trade liberalization, otherwise, grain planting of China will suffer serious impact, lose grain control power, increase risk of grain supply, which are not favorable for long-term safeguard of grain security. Therefore, government should take correct intervention measures and energetically support domestic grain industry^[47]. Sun Lin analyzed characteristics of major grain exporters in implementing export limitation policy, influence of grain export limitation on grain security, internal drawbacks of WTO/GATT multilateral trade negotiation mecha-

nism, and accordingly came up with the new idea of restricting grain export from the perspective of regional cooperation^[48]. Chu Qingquan *et al.* believed that changes of China's grain import and export volume, and changes of grain import and export structure reflect moderately increasing grain import is a necessary, economical and effective choice for ensuring China's grain security^[49]. Yang Peitong analyzed the influence of grain finance on China and proposed strategies for keeping China's grain security in financial globalization^[50]. Yin Changbin introduced major contents and support methods for construction of regional grain security system, and stated that it is required to set up benefit coordination mechanism in grain production and sales region, to promote building of long-term stable grain production and sales cooperation relationship in major grain production and sales areas^[51].

2.4 The relationship between grain subsidy policy and grain security Since the entry into the new century, there have been great changes in environment and conditions of agricultural development. To ensure grain security and increase farmers' income, grain subsidy emerges, and some experts have undertaken a lot of researches in grain subsidy policies. Yang Jianli elaborated performance of direct grain subsidy policy, analyzed the limitation of direct grain subsidy policy that uncouples sown area and price but connects actual planting area and grain sales volume, and proposed the idea of implementing progressive subsidies through connecting area of farmers operating land and grain sales volume^[52]. Li Yong *et al.* found that financial expenditure for producing 10 000 tons of grain was increasing in 1995 – 2005; by 2020, it will need 5 million yuan for producing 10 000 tons of grain, and the total financial cost for grain security will reach 300 billion yuan^[53]. Studies of Chen Fei *et al.* show that various agricultural policies have significantly positive influence on grain production, and agricultural expenditure policy and rural fixed assets investment are important factors for promoting increase of China's grain yield^[54]. Using 199 survey samples of rice farmers in Zhejiang, Anhui and Jiangxi provinces, Yang Wanjiang *et al.* made an empirical analysis on influence of grain subsidy policy on enthusiasm of rice farmers for planting. They concluded that the subsidy plays a significantly positive role in raising enthusiasm of farmers for planting rice^[55]. Zhang Qin believed that direct grain subsidy has positive effect on grain production, in other words, the direct grain subsidy plays a great role in raising enthusiasm of farmers for planting and stimulating farmers to conduct grain production^[56].

2.5 The relationship between agricultural science and technology and grain security The fundamental approach for agricultural development lies in sci-tech progress. Science and technology constitute a primary productive force, fundamental support for ensuring national grain security, and also the decisive force for speeding up construction of modern agriculture^[57]. Science and technology play a great role in promoting agricultural development, increasing farmers' income, and making farmers get rich, as well as increasing integrated grain production capacity. Many domestic scholars have analyzed influence of agricultural science and tech-

nology on grain security, and have made certain research achievements. Zhang Chaohua overviewed China's agricultural policy since the foundation of new China. He summarized 4 development stages of China's agricultural policy and the common core part of these 4 stages is national grain security and farmers^[58]. In the opinion of Fu Zeqiang, when input of materials and technologies is relatively low, changes of farmland resource highly restrict grain production, showing that total grain yield increases with increase of farmland area and reduces with shrinkage of farmland area; when input of materials and technologies is relatively high, the restriction of farmland resource to grain production will be weakened, showing that changes of total grain yield are out of step with changes of farmland area. These indicate that high input of materials and technologies plays a leading role in total grain yield, while the function of farmland area ranks the second position^[59]. Du Zhifeng studied current situation of conversion and extension of agricultural sci-tech achievements, existing problems and future development trend in Zhejiang Province, and came up with the recommendation that Zhejiang Province should attach importance to high yield, high efficiency and ecological safety, to constantly increase grain yield and effective supply capacity of agricultural products^[60]. Li Ping concluded that speeding up construction of modern agricultural industrial technological system has special significance to ensuring grain security and increasing agricultural efficiency and farmers' income^[61]. Yang Fengxia stated that science and technology play important role in agricultural development, the contribution of sci-tech progress to agricultural development is up to 48%, and the sci-tech innovation plays a great role in safeguarding China's grain security, ecological security, promoting increase of farmers' income, and driving transformation of traditional agriculture to modern agriculture^[62]. Zhang Jing studied growth characteristics of agricultural sci-tech innovation efficiency in eastern, central and western areas of China, and concluded that regional unbalance of agricultural sci-tech innovation efficiency will ultimately influence effective supply of basic necessities including grain, oil and cotton, and national grain security^[63]. Xin Xianfei stated that ensuring grain security, increasing integrated grain production capacity and increasing agricultural market force involve various works of agricultural and rural development, urgently need support of agricultural sci-tech progress and speed up conversion of agricultural sci-tech achievements^[64]. Liu Jia pointed out that agricultural science and technology has become the primary productivity force of agricultural development, and application and extension of agricultural science and technology are helpful for increasing land output ratio, resource utilization rate and integrated grain production capacity^[65].

3 The relationship between industrial structure and grain security

With sustainable and healthy development of China's social economy, there will inevitably changes in industrial structure and internal agricultural structure. Transformation of industrial structure re-

sults in loss of rare agricultural resources, pulls growth of demand of agricultural products, leads to drop of integrated grain production capacity and increase of grain demand, accordingly it exerts unfavorable influence of grain security. Some experts of industrial economics and agricultural problem have carried out researches about changes of industrial structure and regional grain security of China from theoretical and practical levels. Wang Jiaxin stated that adjustment of agricultural structure of Jiangsu Province based on comparative disadvantage and surplus of grain is not merely reduction of grain production, it is also accompanied with destruction of grain production resources. Thus, it is required to make effort in keeping adjustment of industrial structure and big grain strategy^[66]. Hu Ronghua analyzed influence of adjustment of industrial structure on grain production and grain security taking Jiangsu Province as an example from changes in structure of three industries, changes in internal agricultural structure, and discussed countermeasures for ensuring grain security in adjustment of industrial structure of Jiangsu Province^[67]. Feng Zhiqiang studied grain security and adjustment of agricultural structure of Henan Province, analyzed problems in the process of stabilizing grain security and agricultural structural adjustment, and came up with recommendations including effectively allocating agricultural resources, adjusting structure of product types, adjusting structure of industrial levels, developing leading agricultural enterprises, and setting up farmers' specialized cooperatives^[68]. Wang Xuzhen *et al.* analyzed the conflict between upgrade of industrial structure and grain security, and believed that it is able to realize coordinated upgrade of industrial structure and grain security through agricultural transformation^[69]. Wu Wenheng stated that it is required to connect strengthen of structural adjustment, guarantee level of ecological construction, and acceptance of grain security, and keep proper construction area, proportion and speed, to realize stable and sustainable development of economy and society of Gansu Province^[70]. Guo Ye *et al.* believed that adjusting industrial structure is the only way for major grain production region to shake off poverty^[71]. Ma Songlin concluded that upgrade of industrial structure significantly increases per unit area yield of grain, reduces crop planting area, and increases grain yield^[72]. Wang Zhuqin found that industrial structure has significant influence on crop planting area of the whole country, especially central and western regions^[73].

4 The relationship between urbanization, industrialization and grain security

Urbanization is the process of comprehensive development of society, economy and culture, and urbanization development is a double-edged sword for grain security^[74, 75]. Some researchers have discussed and analyzed grain security in the context of urbanization and industrialization. For example, Du Yuneng stated that when urbanization, industrialization and agricultural modernization are acted on grain security jointly, the support of industrialization for grain security is greater than its pressure, and urbanization has

significantly negative influence on grain security, while agricultural modernization is weak in supporting grain security^[76]. Wang Hongyu considered that the development of urbanization and industrialization aggravates the conflict with water for agriculture and further worsens the water shortage; urbanization process leads to outflow of numerous rural labors, which not only directly influences agricultural production, but also promotes transformation of grain producers to grain consumers, and accordingly increases pressure of grain supply^[77]. Liu Hui elaborated the influence of urbanization on grain production capacity and grain security, discussed grain security resulted from urbanization process from resource, market and policy, analyzed possible risks of grain security in the urbanization process, and put forward measures including strengthening farmland protection, enhancing agricultural infrastructure construction, reinforcing environmental control, reforming grain reserve system, and strengthening international cooperation^[78]. Shu Jianling pointed out that urbanization restricts grain security from the trend of coupling development, thus government should pay attention to setting up a long-term mechanism for coordinated development of land use efficiency in the process of urbanization^[79]. Guo Bing found that urbanization induces grain production resource like farmland to move to non-agricultural sectors, threatens grain security, and grain security, as a restrictive condition, will also influence urbanization process^[80]. In the opinion of Yang Zhihai, at the national level, county-wide urbanization has significant positive role in grain security; at regional level, urbanization of central and western regions can significantly raise grain security; non-agricultural employment in western regions exerts significantly negative influence on grain security^[81]. Wang Shihai, from the perspective of urban and rural population flow, analyzed China's grain security. He said that promoting migration of rural residents to urban areas plays a positive role in ensuring grain security due to difference of urban and rural people in production, living habits and ways^[82]. Ye Hui *et al.*, on the basis of analyzing interaction of urbanization and grain security, set up dynamic coupling model for coordinated development of urbanization and grain security. They divided the coordination between urbanization and grain security into 4 stages. From now, it is required to pay close attention to the mutual restraint between urbanization and grain security and set up long-term mechanism for coordinated development of urbanization and grain security^[83].

5 The relationship between ecological protection and grain security

Destruction of ecological environment results in shrinkage and degradation of farmland, leads to reduction of integrated grain production capacity, and influences grain security. Some scholars of ecological field have made related researches about influence of ecological changes on grain security. He Jinhong believed that conceding the land to forestry (grassland) has direct influence on constant drop of grain yield in Loess Plateau areas, and it is inappropriate to expand the farmland conceding area, but conceding the

land to forestry (grassland) will not pose a big threat to grain security of Loess Plateau areas^[84]. Liu Xianzhao *et al.* surveyed the relationship between conceding the land to forestry and reduction of farmland area and obtained that conceding the land to forestry results in drop of grain yield for 1.5%. However, conceding the land to forestry improves ecological environment, reduces water loss and soil erosion, so it also increases per unit area yield especially capital farmland in hilly and slope land. With two parts offsetting, the total reduction of grain yield was only 0.5%^[85]. Hu Zhenqi analyzed in depth main problems of mineral and grain composite area, such as aggravation of environmental pollution, destruction of farmland, reduction of grain yield and quality, prominent social conflict, and sluggish economic development, and put forward countermeasures and recommendations from understanding, awareness, safeguard, and technology aspects^[86]. In the opinion of Dong Mei, on short terms, conceding the land to forestry does not seriously influence China's grain security; on long terms, on the basis of ensuring per capita grain consumption, it should properly adjusting the scale of conceding the land to forestry^[87]. Zhang Fushan *et al.* summed up development and evolution of concept of the grain security, elaborated various dangers of harmful organism to grain security, discussed great contribution of plant protection to grain security, analyzed negative influence of chemical pesticide on grain security and possible risk of herbicide resistant transgenic crop to grain security, concluded plant protection is an essential factor influencing grain security, and put forward countermeasures for promoting grain security^[88]. On the basis of systematic survey and experimental observation of sewage irrigation areas in Kaifeng City of Henan Province, Zhou Zhenmin built the ecological environment and grain security risk evaluation indicator system, studied risks of ecological environment and grain security in sewage irrigation areas, and pointed out both ecological environment and grain in Kaifeng City are seriously polluted by heavy metals (for example, wheat is seriously polluted by Pb, Cd, Cr and As)^[89]. Wu Lichao *et al.* analyzed current situation of farmland and soil pollution in the rapid urbanization of China in recent three decades, and the grain security resulted from farmland shrinkage and soil pollution, analyzed the influence of changes of land use structure, urban rubbish, acid matter, and water pollution in the process of rapid urbanization on farmland and grain security^[90].

6 Brief comments

At present, domestic researches on China's grain security mainly focus on resource, policy, industrial structure, urbanization and industrialization, ecological protection and grain security. In the aspect of resource and grain security, it includes farmland resource, water resource, and climate resource and grain security. In policy and grain security, it incorporates grain reserve, grain security pre-warning, grain trade and finance, grain subsidy policy and agricultural science and technology. In the farmland resource and grain security, it involves the relationship between

farmland area and grain yield, and influence of farmland quality on grain yield. As regards water resource and grain security, researches mainly involve importance of water resource to grain security and taking effective water-saving measures to safeguard grain supply. In climate resource and grain security, it mainly includes harmful influence of global warming on grain production. For biomass resource and grain security, researches are concentrated on mitigating influence of the biomass energy on grain security. For grain reserve and grain security, main researches touch on importance of grain reserve, adverse influence of reduction of grain reserve, the volume of grain reserve and types of grain reserve since the grain reform. As to grain security pre-warning and grain security, it mainly includes grain security pre-warning system, model and mechanism, and grain monitoring pre-warning system. With regard to grain trade, finance and grain security, it mainly relates to limiting export, moderate import, setting foot on self-sufficiency, and grain finance, to provide financial support for grain production. In grain subsidy policy and grain security, studies mainly touch upon positive influence of grain subsidy policy on grain production, and limitation of some grain subsidy policies. About agricultural science and technology, research achievements are focused on agricultural sci-tech policies, conversion of agricultural sci-tech achievements, application and extension of agricultural science and technology, agricultural sci-tech input, and efficiency of agricultural sci-tech innovation since the reform and opening-up. Concerning industrial structure and grain security, it is stated that adjustment of industrial structure will increase farmers' income, but influences grain yield. As for urbanization, industrialization and grain security, studies mainly touch upon unfavorable influence of urbanization and industrialization on grain security and focus on functions of urbanization of different regions to grain security. In ecological protection and grain security, researches mainly focus on dual influence of conceding farmland to forestry on grain security, and adverse influence of environmental pollution, plant diseases and insect pests, and sewage irrigation on grain security. Through detailed overview of domestic literature, it is expected to provide theoretical basis for adjusting agricultural industrial structure, formulating grain development policy, and ensuring grain security.

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