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# Key Strategic Issues Regarding Agricultural Resources and Environment in China

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**Abstract:** In the middle of the 21st century, China will be in a period of comprehensive modernization and globalization. China will face an aging population as well as shortages of labor and resources. The disparity between the population and the amount of resources will be large, and environmental governance will become very difficult. To ensure the security of food, resources, and ecological environment, the Chinese Academy of Engineering set up a major consulting project called "Research on Key Strategic Issues of Agricultural Resource and Environment in China" to analyze the situation and seek countermeasures. In accordance with the central government's new development concept of "innovation, coordination, green, openness, and sharing," this project proposes three strategic directions: "full implementation of the agricultural innovation-driven strategy," "in-depth promotion of the agricultural sustainable development strategy," and "implementation of the agricultural globalization strategy." Moreover, 8 strategic changes, 16 strategic measures related to resource conservation, environmental protection, structural adjustment, and regional distribution, and 10 major projects are proposed.
**Keywords:** agricultural resources; ecological environment; China

## 1 Introduction

The achievements of Chinese agriculture have attracted worldwide attention, as it has succeeded in feeding approximately 1.4 billion Chinese citizens while making major contributions to global agriculture. However, problems have emerged in the agricultural resource environment of China, and the constraints imposed by these problems are becoming increasingly severe. The agricultural sector is facing a shortage of arable land and water resources, inadequate agricultural resource quality, increasing levels of environmental pollution, and frequent natural disasters. Owing to these problems, the agricultural resource environment of China is in an overloaded state. Additionally, the agricultural workforce is aging, reducing the overall quality of the workforce. Rapid increases in the agricultural cost of production have also reduced the competitiveness of China's agricultural sector. In summary, the agricultural production of China

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is in an unstable, insecure, and unsustainable state. Although the degradation of the agricultural resource environment is partly caused by natural factors, human factors have played a far larger role in this regard. Much of this degradation can be attributed to the long-term prioritization of agricultural production over environmental protection and an emphasis on quantity over quality, which has led to extensive agricultural practices that sacrifice resources, environmental quality, and harmonious development for short-term production gains.

## 1.1 Agricultural resource shortages have become a major obstacle against sustainable agricultural development

### 1.1.1 Quantity and quality of arable land are decreasing over time

The area of arable land in China decreased from $2.031 \times 10^9$ mu (1 mu ≈ 666.667 $m^2$) in 2009 to $2.025 \times 10^9$ mu in 2015. At the national level, the total amount of backup arable land resources that can be cultivated in the near-term is only $3.307 \times 10^7$ mu. The arable land resources of China also tend to have low quality; in 2015, excellent and high-grade land accounted for only 29.4% of China's total arable land, whereas medium and low-grade land accounted for 70.5% of the total. Furthermore, the arable land that is being converted into non-agricultural land tends to have high quality, whereas the land that is being converted into arable land usually has low quality. A total of $3 \times 10^6$ $hm^2$ of China's high-quality land resources were converted into non-agricultural land between 1996 and 2009, and 80% of these conversions occurred in Central and Eastern China. The replacement of high-quality arable land with low-quality arable land over the past 20 years has reduced the total productivity of China's arable land by approximately 2%.

### 1.1.2 Scarcity of water resources has become a significant constraint for agricultural production

The agricultural sector is facing water shortages due to the pressure exerted by non-agricultural water usage. The amount of water resources of China per capita is only 2 034 $m^3$, which is less than 25% of the world average. Furthermore, the proportion of agricultural water consumption in the total water consumption of China is decreasing over time. Northern and Southern China accounted for 18.8% and 81.2% of the multi-year average water resources in China, respectively. However, the farmlands of China are gradually moving toward the north, resulting in exacerbated stress levels on the water resources of Northern China. Furthermore, groundwater extraction and crop irrigation are intensifying across China. Other than the Songhua River area, the water-use intensities of all northern regions have exceeded the internationally accepted 40% warning threshold. The water-use intensity of Northern China is the highest in China (118.6%), which signifies a severe level of water over-extraction.

## 1.2 Quality and quantity of labor resources are declining owing to aging population

The migration of youth toward cities and non-agricultural sectors has led to the aging and feminization of the agricultural workforce. The proportion of 16–39-year-olds in the agricultural workforce decreased from 65.3% in 1990 to 37.8% in 2010. In 2010, there were more female workers than male workers in the 20–49-year-old age bracket. Furthermore, the gap between the agricultural workforce and the national employed population with regard to average years of education has gradually increased over time, from 0.92 years in 1982 to 1.49 years in 2010.

## 1.3 Agricultural environment is becoming increasingly polluted, and frequency of natural disasters is increasing

The severity of soil pollution is increasing across China, as agricultural soil contamination has increased from <5% in the late 1980s to 19.4% at present (according to the *Report on the National General Survey of Soil Contamination*). This has led to concerns regarding the health and quality of agricultural products. Additionally, many of China's water bodies are heavily polluted, which has resulted in widespread nonpoint source pollution. According to the *2015 Report of the Ministry of Environmental Protection on the State of the Environment in China*, Grade IV–V and Bad V water quality sections accounted for 26.7% and 8.8% of all the national surface water-monitoring sections, respectively. Agricultural waste (e.g., livestock and aquaculture waste, straw, and residual plastic films) has become a significant source of pollution, as it has not been adequately repurposed as utilizable resources. Furthermore, natural disasters are becoming increasingly frequent across China, including (1) droughts, floods, heat waves, and cold snaps; (2) geological disasters such as landslides, mudslides, and earthquakes; (3) agricultural disasters such as smog, soil and water loss, rocky desertification, secondary soil salinization, and waterlogging; and (4) invasive species.

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## 2 Strategy for securing agricultural resource environment of China

### 2.1 Guiding ideology and fundamental principles

2.1.1 Guiding ideology

The strategy to secure China's agricultural resource environment will be guided by the tenets of innovation, harmony, environmental friendliness, openness, and sharing, to fully realize the ambitions of the 19th National Congress. This approach is necessitated by current conditions. The modernization and globalization of Chinese agriculture will inevitably lead to new problems, conflicts, and challenges, as well as new opportunities. The use of new development concepts will be necessary for solving the problems that arise throughout this process.

2.2.2 Fundamental principles

(1) Adhere to bottom-line thinking to ensure food security.

(2) Adhere to the principle of integrated land cultivation and rehabilitation to safeguard the ecological environment of China.

(3) Adhere to integrated exploitation and conservation, with an emphasis on conservation.

(4) Always tailor actions to local conditions and optimize the allocation of resources.

### 2.2 Strategic directions

2.2.1 Fully implement innovation-driving strategy for agricultural sector

The primary aim of the innovation driving strategy is to address the lack of development drivers in the agricultural sector. In the short term, agricultural supply-side structural reforms will be the main focus of this strategy. This entails a shift of emphasis from production-boosting developments to quality-enhancing developments, to realize growth model transformation and structural reforms in the agricultural sector, thus increasing land productivity, resource efficiency, and workforce productivity in the agricultural sector. This will enhance the quality and effectiveness of agricultural development.

2.2.2 Implement sustainable development strategy of agricultural sector

Sustainable utilization of the agricultural resource environment will be necessary for sustainable agricultural development. The objective of the agricultural sector's sustainable development strategy is to achieve the harmonious development of mankind and nature, thereby leading to an ecofriendly agriculture resource environment that is healthy, secure, and sustainable. To comprehensively address the root causes of the environmental problems of the agriculture sector, it is necessary to promote the conservation of agricultural resources, clean production processes, industrial chain circularization, and the conversion of waste products into resources. The objective of these measures is to create an agricultural production system that is resource-efficient and ecofriendly, for producing green agricultural products.

2.2.3 Implement "Go Global Policy" in agricultural sector

The opening of Chinese agriculture to international markets should be expanded to allow its development to be simultaneously driven by international and domestic markets. This will help to balance the global population–resource–food equilibrium and contribute to the development of a "community with a shared future for mankind." To implement the "Go Global Policy" in the agricultural sector, it is necessary to establish a globally oriented China-based agricultural sector according to the "new vision for common, comprehensive, cooperative, and sustainable security." A win–win scenario may be achieved by coordinating international and domestic agricultural developments to maximize the strengths of each country, thus establishing a community with a shared future for mankind. The implementation of the "Go Global Policy" must be guided by the Belt and Road Initiative. Agricultural cooperation should be initiated with China's neighboring countries, particularly those located along the Belt and Road corridors. Partnerships with countries that are traditionally known for agriculture should be maintained. In this way, several "global granaries" can be constructed in cooperation with other countries around the world to safeguard the food security of mankind.

### 2.3 Strategic transformations

Chinese agriculture will undergo a major revolution in the first half of the 21st century. The following eight strategic transformations in the production and resource utilization modes of Chinese agriculture are readily achievable.

(1) The transformation of conventional extensive agriculture into resource-efficient, ecofriendly, and high-quality high-efficiency modern agriculture

(2) The transformation of labor-intensive agriculture into knowledge-, technology-, and capital-intensive agriculture

(3) The conversion of conventional agricultural land use into mixed grassland–cropland land use, based on the use of pasture–crop rotations

(4) The transformation of low-efficiency extensive irrigation agriculture into modern irrigation agriculture with efficient adaptive production systems

(5) The introduction of controlled-environment agriculture (CEA) to conventional land agriculture

(6) The conversion of small, scattered farms into large-scale collective farms

(7) The unification of previously disparate urban and rural agriculture into town-based urban–rural agriculture

(8) The transformation of Chinese agriculture into an open and globalized China-based agricultural sector, where the agriculture sectors of individual countries are coordinated to complement each other

## 2.4 Strategic targets

### 2.4.1 Overall targets

The overall aim of the strategy to secure China's agricultural resource environment is to convert extensive agricultural operations into intensive agricultural operations, thus transforming traditional agriculture into modern agriculture. This will facilitate the construction of an agricultural resource environment and modern agricultural system that are resource-efficient, ecofriendly, rationally structured, urban–rural integrated, and internally/externally coordinated, therefore laying the foundations for achieving the Two Centenaries of China.

### 2.4.2 Targets for 2030

(1) Increased agricultural-resource security: By 2030, the total arable land resources of China should be maintained at $1.9 \times 10^9$–$2 \times 10^9$ mu, and the amount of water used for irrigation should be restricted to $3.73 \times 10^{11}$ $m^3$. The effective irrigation area in farmlands should reach $1.035 \times 10^9$ mu, the area subjected to water-saving irrigation should be approximately $8.5 \times 10^8$ mu, and the area subjected to high-efficiency irrigation should reach $5.0 \times 10^8$ mu.

Although the stress on arable land resources and irrigation water resources should decrease to a certain extent by 2035 owing to the shrinking national population, the arable land resource situation of China remains dire.

(2) Significant improvement in the resource efficiency of agriculture: The effective utilization coefficient of irrigation water should be increased to ≥0.60, and food production per unit area of irrigation should exceed 1.60 kg. The amount of agricultural fertilizer should be restricted to $4.6 \times 10^7$ t. The fertilizer and pesticide efficiency should be increased to ≥50%. The comprehensive utilization of agricultural straw should be increased to ≥90%, and the recycling rate of agricultural plastic films should be ≥80%. Finally, comprehensive livestock waste utilization should be increased to ≥75%.

(3) Efforts to ameliorate the outstanding problems of China's agriculture environment should begin to produce results: The environmental quality of farmlands across China should stabilize and improve, and effective safeguards should be put in place to ensure the environmental security of farmlands, so that the environmental risks faced by important farming areas are controlled in all aspects. The percentage of contaminated farmlands that are safe for cultivation should exceed 95%, and the soil environment quality of farmlands across China should improve as a whole.

(4) The agricultural ecosystem should be restored and strengthened to an extent: Effective measures should be implemented to prevent regional water and soil loss, sandy desertification, and rocky desertification, while grassland degradation/desertification and fishery "desertification" should be contained in an effective manner.

(5) Optimization of agriculture structures: The construction of the modern agricultural production system should be near completion, and the development of agricultural product processing and distribution industries should progress rapidly. The developments of the agricultural sector should be diversified, so that the various functions of the agricultural sector can be fully developed. The development of primary, secondary, and tertiary industries should be integrated through the integration of agriculture, forestry, animal husbandry, and fisheries, as well as the unification of processing and farming industries. In this way, a three-part system consisting of food crops, economic crops, and animal-feed crops should be formed across China.

### 2.4.3 Importance and feasibility of maintaining $2 \times 10^9$ mu of arable land

Based on land carrying capacity calculations, China must maintain $1.9 \times 10^9$–$2 \times 10^9$ mu of arable land to achieve a

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food self-sufficiency rate of ≥80%. In previous decades, the amount of arable land in China has always been >2 × $10^9$ mu, and the average amount was approximately 2.035 × $10^9$ mu. Put differently, in the last 40 years, the large-scale production of food crops and other agricultural products in China has always been supported by >2 billion mu of arable land. Thus, securing a minimum of 2 × $10^9$ mu of arable land is a basic requirement for achieving self-sufficiency with regard to food crops and other important agricultural products. Between 2009 and 2015, the total amount of arable land in China decreased by 6 × $10^6$ mu, from 2.031 × $10^9$ to 2.025 × $10^9$ mu; the average loss of arable land each year was approximately 1 × $10^6$ mu. Therefore, the unordered expansion of urbanization must be limited. Construction lands for cities and villages must be obtained by employing internal reserves and by increasing utilization rates and floor area ratios. In summary, the retainment of 2 × $10^9$ mu of arable land in 2030 is a readily achievable target.

## 3 Strategic pathway for safeguarding security of China's agricultural resource environment

### 3.1 Establish ecofriendly development modes

#### 3.1.1 Development of circular, low-carbon agricultural sector by promoting circularization of agricultural resource usage

Agricultural resource conservation should be promoted by reducing water, land, fertilizer, energy, pesticide, and labor usage to improve the efficiency of water resources, land resources, and agricultural inputs. Circular agricultural supply chains should be established by promoting integrated crop planting and livestock breeding, combined farming and grazing, the combination of livestock farms and fields in an organic manner, and the mixing of agriculture with forestry, animal husbandry, and fishing. An agricultural waste utilization system should be established with a focus on straw recycling for ruminant livestock, the use of livestock manure, and the development of biogas plants.

#### 3.1.2 Comprehensively remediate nonpoint source pollution by eliminating pollution sources and integrating preventive and rehabilitative measures

Fertilizer and pesticide use should be reduced by one-third, and soil test-based fertilizer application should be promoted to ensure that this technique is used in all farmlands. Highly effective low-risk pesticides should be popularized, and the intensity of pesticide usage should be reduced. Livestock and aquaculture sites should be laid out in a rational manner, in suitable lands and water bodies, respectively. According to a comprehensive analysis, each hectare of farmland in China can bear 30 tons of livestock manure, and the maximum amount of nitrogen and phosphorus that can be applied in each unit area of farmland is 150 kg/$hm^2$ and 30 kg/$hm^2$, respectively. Considerable effort should be directed toward addressing the pollution caused by residual plastic films and the conversion of straw into resources, fertilizer, feed, substrates, raw materials, and energy.

#### 3.1.3 Full-scale implementation of soil-contamination surveys and pollution-control measures, with focus on heavy-metal contamination

Soil-contamination surveys should be conducted with an emphasis on farmlands, to reveal the areas, types, and degrees of contamination in the farmlands of China. Additionally, a regular survey system should be established to monitor the soil environmental quality across China. Pollution prevention and mitigation measures should be undertaken according to the principles of "prevention, protection, and risk management," and appropriate management and remediation measures must be taken in high-risk areas and heavily contaminated areas. Comprehensive remediation projects should be implemented in areas where soil contamination is particularly severe, such as the Beijing–Tianjin–Hebei region and Yangtze River Basin.

#### 3.1.4 Development of new agricultural resources

Sustainable water resources and brackish water resources should be developed in a scientifically informed manner to increase the availability of irrigation water sources. Tidal flat resources should be developed rationally, to find a new method that outstrips the traditional "reclamation–planting–breeding" mode of development with regard to productivity per unit area of tidal flat. The revitalization and development of "hollow villages" should be strengthened; the comprehensive improvement of agricultural village lands (with a focus on the revitalization of hollow villages) should be included in the rural revitalization strategy. Pelagic and polar fishery resources should be exploited, and the development of marine technologies should be pursued, for enhancing China's capacity to acquire fishery resources.

### 3.2 Strengthen technological support systems

3.2.1 Development of water-conserving agricultural techniques based on regulated deficit irrigation, to achieve irrigation of $1 \times 10^9$ mu of farmland

To irrigate $1 \times 10^9$ mu of farmland, the water consumption of the primary food-crop production areas must be reduced by approximately 60–80 $m^3$ per mu by 2030. Therefore, it is necessary to insist on careful development based on water-resource measurements, prioritize water conservation, and promote water-conserving agricultural techniques based on regulated deficit irrigation. The first step is to actively develop and promote high-efficiency irrigation technologies such as sprinkler irrigation, micro-irrigation, and piped irrigation, as well as technologies for the control of canal seepage. The second step is to develop methods for regulated deficit irrigation; according to preliminary estimates, the propagation of regulated deficit irrigation to the $3.09 \times 10^7$ mu of farmland in Hebei could reduce water use by $1.07 \times 10^9$ $m^3$, which is 17.8% of the total groundwater overdraft of the province ($6 \times 10^9$ $m^3$). The third step is to implement controls and quotas on the total amount of water used for irrigation, for allowing the management and conservation of water resources.

3.2.2 Establish scientifically informed fertilizer application guidelines for organic and inorganic fertilizers, with strong emphasis on organic fertilizers

Inorganic fertilizer-dominated fertilizer-management strategies should be replaced by encouraging farmers to use straw-based fertilizers, organic fertilizers, and green manuring, which increase the soil organic-matter content. According to a long-term study performed by the Institute of Soil Science of the Chinese Academy of Sciences, the soil organic-matter contents of dry and irrigated fertile soils in Northern China, fertile paddy soils in Southern China, and fertile black soils in Northeastern China are 1.2%–1.5%, 2.5%–3.5%, and 4.0%–6.0%, respectively. These values may serve as references for the measurement of farmland soil fertility in the corresponding regions of China. The development of soil-fertility projects should be intensified, and it is important to adopt “double balancing” policies that will balance the occupation and supplementation of arable lands while promoting soil balancing.

3.2.3 Drive modernization of agricultural sector via agricultural informatization and intensify efforts to promote technological innovations

The study and application of agricultural intelligentization, mechanization, and automation must be accelerated if China is to catch up to the international level and welcome the future of agriculture. Informatization should be used to nurture new farmers, reshape the agricultural sector, and transform rural areas. It is also important to establish a full-coverage rural information highway, whole-industry-chain digital agriculture, and a space-terrestrial agriculture monitoring and management system. Finally, government coordination is necessary for making full use of the market to promote the integrated development of informatization and agricultural modernization.

3.2.4 Improve agricultural education and farmer training to increase farmer quality

Farmers are the backbone of the agricultural sector. Therefore, it is of utmost importance to implement farmer education and training programs that include practical technology training, vocational skill training, innovation training, and academic education. Agrobusinesses, professional cooperatives, and other organizations that satisfy legal requirements should be encouraged to participate in farmer training. In this way, a farmer education and training system that connects and involves all levels of society will gradually take form. Additionally, innovation training should be implemented to enhance the applicability of the farmers’ education.

### 3.3 Improve structures and systems of modern agricultural sector

3.3.1 Vigorously develop animal fodder cultivation and readjust structure of agricultural sector

The essence of the food security problem is the animal feed problem, as the “feed crisis” is a fundamental threat to the food security of China. It has been forecasted that the food self-sufficiency rate of China will be 105% in 2030, which is more than sufficient for China’s demands. However, there is a large gap in China’s fodder supplies, as the fodder self-sufficiency rate of China is only 68.3%. Thus, it is necessary to include animal feed and fodder in the agricultural system by transforming the current “food crop–economic crop” structure of Chinese agriculture into a “food crop-economic crop–feed crop” structure and by constructing a composite seed-nutrient production system that will simultaneously supply human food and animal fodder. This will transform the conventional “food crop” paradigm of Chinese agriculture into a “food equivalent” paradigm.

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It has been estimated that $7 \times 10^8$ mu of high-productivity grain-growing area is sufficient to produce 210 kg of grain rations, feed grain, and standing grain per person. By converting the remaining grain-growing areas into animal fodder-producing areas, the total fodder production of China can exceed $1 \times 10^9$ t, which would satisfy the needs of the livestock industry. Specialized fodder-production projects should be implemented. In Northern China, the conversion of crop-production areas into fodder-production areas should be encouraged and propagated, and guidance should be provided for the production of high-quality fodder, such as whole corn silage, oat, broom-corn, and medick. In Southern China, grass planting and green manure cultivation should be promoted in winter fallow fields.

3.3.2 CEA should be actively developed

CEA is crucial for overcoming the constraints of the agriculture resource environment (with regard to water, soil, light, and temperature), increasing farmer income, and developing a modern agricultural sector. At present, CEA occupies <5% of the arable land in China and yet produces 39.2% of China's total agricultural output. Therefore, CEA development should be pursued with vigor. First, it is important to increase support for the CEA industry by promoting technological innovation and equipment upgrades. Second, specialized talents should be nurtured to enhance the quality of the CEA workforce.

3.3.3 Prioritize development of export agriculture

The production of technology-intensive and labor–technology-intensive agricultural products such as high-yield vegetables, ornamental plants, fruits, and fishery products should be developed vigorously, under the provision that domestic food-crop production will not be compromised. Large amounts of products may then be exported to the international market while satisfying domestic demand. This will reduce China's agricultural trade deficit and contribute to the food security of the world. To this end, it is necessary to strengthen information-gathering efforts and market research with respect to the international agriculture market. Furthermore, scientific research should be intensified, particularly research on the development of CEA for export agriculture. Government support for export agriculture (policies and funding) should be increased.

3.3.4 Leisure agriculture and rural tourism should be developed

Leisure agriculture is a new aspect of modern agriculture and is an important approach for increasing farmer employment and income. Efforts should be made to highlight the diversity, history, and charm of Chinese agriculture. Policies that support leisure agriculture should be improved, and the financial requirements for developing this industry must be prioritized. Infrastructure such as roads, water supplies, and sewage treatment facilities should be improved. The localization of key processes, e.g., food processing and services, should be promoted, and it is important to create distinctive themes and a diversity of characteristics in leisure agriculture to prevent monotony.

### 3.4 Optimization of spatial layouts

3.4.1 Establishment of new town system that is suitable for upscaling agriculture and rural economy collectivization

At present, the expansion of ultra-large and very large cities has led to a series of "urban diseases," which are occurring concurrently with "village disease," i.e., the weakening, decay, and "hollowing" of many small towns and villages. These issues have widened the gap between urban and rural areas in China. Therefore, the development of ultra-large cities must be stringently restricted. The support for small-town development should be enhanced, with priority given to the development of county-level towns. In this way, a coordinated state of development will be achieved among large, medium, and small cities. According to the concept of urban–rural integration, secondary and tertiary industries should be guided to operate in key county towns, cities, and industrial parks, promoting the integration of rural industry development with new urbanization to bring about integrated urban–rural development. Furthermore, it is necessary to tailor all actions to local conditions. Urban development modes with distinct characteristics should be explored to facilitate the construction of a livable system of towns.

3.4.2 Implement national food production layout to "improve Northeast China, manage Northern China, and restore Southern China"

The food-crop production of Northeast China, Northern China, and Southern China account for 78.3% of China's total food-crop production. It is expected that Northeast China will remain as China's largest commodity grain-production base with regard to grain production potential and commodity rate, in both the short and long terms. Northern China is the largest grain-production base in China, but the water shortages and environmental degradation faced by this region are the most pronounced among all major food-producing regions in China. Southern China is the primary food-consuming region of China; consequently, this region has the widest supply–demand gap in China. According to the features and issues of the resource environment in these regions, agriculture informatization should be used to increase the level of agricultural mechanization and automation in Northeast China. Additionally, the construction of large commodity grain bases and high-quality milk-production bases in reclamation areas such as the Heilongjiang Reclamation Area should be accelerated. In Northern China, regulated deficit irrigation should be fully implemented, as well as efficient water-saving irrigation techniques such as sprinkler irrigation, micro-irrigation, piped irrigation, and fertigation. Furthermore, actions should be taken to prevent and mitigate air, water, and soil contamination. In Southern China, the "de-agriculturalization" of arable lands must be prevented to stabilize the area covered by paddy fields. Moreover, practices such as double rice cropping and green manuring should be revived in this region.

3.4.3 Establish eight national-level agricultural production zones

According to the distribution of agricultural resources across China, the Sanjiang Plain, Songnen Plain, eastern Inner Mongolia, Huang–Huai–Hai Plain (North China Plain), Middle Yangtze Plain and Jianghuai region, Sichuan Basin, Xinjiang cotton-growing area, and Guangxi sugarcane production area have the best agricultural resource conditions of China. The arable lands of these regions account for approximately 50% of China's total arable land. Furthermore, the wheat, corn, rice, oil crop, cotton, and sugar productions of these regions account for 78.4%, 63.8%, 52.3%, 60.4%, 90.4%, and 74.7% of the nation's totals, respectively. Therefore, China should focus on the establishment of national-level agricultural production zones in these eight regions and improve their irrigation and water-conservancy infrastructure, to establish a robust foundation for securing the production and supply of agricultural products in China.

3.4.4 Enhance international collaboration to jointly construct global granary

According to current forecasts, the global population will reach 10 billion by the mid-21st century. The possibility that a global food crisis could occur at this point has become a major source of concern across the globe. Owing to imbalances in the global distribution of human populations and agricultural resources, it is suggested that global granary (food) production bases should be constructed in regions that have strong agricultural foundations, abundant resources, and potential for further development, in order to safeguard the grain and food security of mankind. According to currently available information and infrastructures, the initial design of this plan is to form eight global-scale "granaries": a North American Granary for the U.S. and Canada; a South American Granary for Brazil and Argentina; a Eurasian Granary for Russia and Kazakhstan; a European Granary for France and Ukraine; a Southeast Asian Granary for Thailand, Myanmar, and Vietnam; an African Granary for East Africa; a Pacific Ocean Granary for Australia and New Zealand; and an Edible Oil Base for Indonesia and Malaysia.

Through international collaboration, China will reduce its reliance on certain source nations for its imported agricultural products and implement a policy of agricultural import diversification.

# 4 Selection of major agricultural projects

## 4.1 Implement projects to protect and establish basic subsistence farmlands

Subsistence farmlands refer to wheat and rice fields. In the period of 2015–2030, China will need a minimum of $7 \times 10^8$ mu of farmland with high and stable yields to safeguard the security of its grain rations. In the short and long terms, the primary production zones that are capable of providing large quantities of commodity grain will be located in the Songnen Plain, Sanjiang Plain, eastern Inner Mongolia, central and southern Liaoning, North China Plain, and the Middle Yangtze Plain. The production zones generally aggregate in the Heilongjiang, Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, and Jiangxi provinces. It is estimated that these production zones can produce $1.98 \times 10^8$ tons of wheat and rice and $1.49 \times 10^8$ tons of commodity grain, which are sufficient (or close to being sufficient) for satisfying the needs of China.

Special protections must be accorded to high-quality arable land in primary grain-production regions, as follows. (1) Non-agricultural uses for arable land must be stringently restricted, particularly in core agricultural regions with high multiple cropping index values. The development of agricultural water-conservancy projects and soil-fertility projects should be intensified, to create high-quality high-standard farmlands with high and stable yields. (2) In the Huang–Huai–

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Hai region, Xinjiang, eastern Inner Mongolia, and Songnen Plain, it is important to intensify the construction of efficient and water-conserving agricultural production systems. (3) The security of the ecosystems that support agricultural production must be protected, and it is important to prevent and remediate ecological disasters such as desertification. (4) Pollutant emissions must be stringently restricted, alongside the implementation of soil-contamination prevention and remediation measures. In areas of severe soil contamination, such as the Middle Yangtze Plain, Jianghuai region, and Huang–Huai–Hai region, precautions must be put in place to ensure soil health and agricultural product safety.

### 4.2 Pilot comprehensive "hollow village" rehabilitation projects

In 2015, the average construction land use of each rural villager in China was 300 $m^2$, which is two times the upper limit of the national standard for per capita construction land use. It is estimated that the rehabilitation of "hollow villages" could increase the potential arable land of China by $1.14 \times 10^8$ mu. "Hollow village" rehabilitation projects should be piloted in economically developed regions such as the North China Plain, the southeastern coastal areas of the Middle-Lower Yangtze Plain, and the Sichuan Basin.

Under the provision that the wishes of the farmers are respected and their land rights are protected, hollow-village rehabilitation projects should be implemented in an orderly fashion and tailored to the different types of hollow villages. Additionally, these projects should first be tested in certain areas before being propagated. Village-rehabilitation projects may be initially implemented in economically developed regions, using an urbanization-led mode of hollow-village remediation. In regions with moderate levels of economic development, remediation should focus on the aggregation of scattered villages and the restoration of unoccupied and abandoned settlements; the land obtained via remediation should then be converted into farmland. In regions where economic development is slow, attempts should be made to control the development of hollow villages by guiding farmers to congregate their settlements; the land obtained via remediation should then be converted into farmland, to help establish large-scale agricultural operations.

### 4.3 Implement modern water-saving irrigation projects in North China Plain

The Haihe Plain in the North China Plain is an important winter wheat production zone for China. However, this region faces severe water shortages, groundwater overdrafts, and environmental pollution. Therefore, there is an urgent need to initiate comprehensive water conservation-based rehabilitation projects in this region and to construct a modern high-precision irrigation regulation and management system.

The productivity of this winter wheat production zone can be stabilized by devising crop planting plans according to the local rainfall characteristics. The area suffering from severe groundwater overdraft ($8 \times 10^6$ mu winter wheat growing area) should be gradually reduced in an appropriate manner. Dry farming could expand the winter wheat growing area in the North China Plain by $5 \times 10^6$ mu and stabilize $>1 \times 10^8$ mu of irrigated wheat fields.

The modernization of irrigation schemes can be achieved via regulated deficit irrigation. Actions should be taken to comprehensively propagate regulated deficit irrigation and chemigation–fertigation techniques, as well as efficient water-conserving techniques such as sprinkler irrigation, micro-irrigation, and piped irrigation. A modern cloud-computing platform for smart irrigation should also be developed. Additionally, $6.8 \times 10^7$ mu of highly drought- and flood-resistant farmlands should be established. Thus, the coverage of water-saving irrigation and high-efficiency water-saving irrigation will reach 91% and 88%, respectively, and the effective utilization coefficient of irrigation water for farmlands should increase to $\geq 0.72$.

Mechanisms based on water-use measurements, such as agricultural water pricing and the confirmation of water rights, should be fully implemented to allow the reform of government policies and measures. Additionally, irrigation water use-based pricing should be comprehensively implemented, to allow the development of precise subsidy policies for agricultural water savings and water use-based reward or penalty mechanisms, thus establishing a modern irrigation-management system. Finally, projects for reducing groundwater extraction should be continued.

### 4.4 Implement grassland engineering projects

At present, the area covered by high-quality forage grass is $<1.5 \times 10^7$ mu. However, the animal husbandry industry is expected to require $4 \times 10^8$ t of high-quality forage grass in 2030; thus, there is a significant gap.

The propagation of grassland-cropping rotation should be tailored to local conditions. In Northeast China, agricultural practices based on food crop–feed (silage or forage grass) rotation should be promoted. In Northern China, a food crop–

economic crop–animal feed (silage/forage grass) rotation should be implemented. In regions of overlap between farming and animal husbandry areas, farming and animal husbandry should be combined, with a focus on animal husbandry, and food crop–animal feed (forage grass/silage) rotations should be implemented. In the arid northwestern oasis regions, a food crop–economic crop (cotton and fruits)–animal feed rotation should be practiced. In grassland-pasture areas, a grassland-dominated food crop–grassland rotation should be implemented. In Southern China, a food crop–green manuring rotation should be implemented.

As the basic capacities of China in grassland science are lacking, it is important to accelerate talent development in various aspects of grassland science (e.g., plant breeding, plant cultivation, mechanization, and scientific foundations), so that China's capabilities in this area will satisfy the requirements of modern agriculture.

### 4.5 Pilot prevention and remediation strategies for agricultural nonpoint source pollution

Seven to nine independent administrative units in primary agricultural production areas such as the Huang–Huai–Hai region and Middle-Lower Yangtze Plain, which are representative of their respective watersheds, should be selected as strategic pilot areas for nonpoint source pollution prevention/remediation strategies. To achieve food-crop safety and protect the environment, strategies such as the restriction of total fertilizer/pesticide use, the control of livestock/poultry farming, and the optimization of crop planting and livestock breeding layouts should be implemented in a few pilot areas. This will encourage farmers to take initiative in remediating nonpoint source pollution and promote ecofriendly agriculture, in addition to the control of nonpoint source pollution. The experience gained from pilot implementations will provide policy references and scientific support for the control of agricultural nonpoint source pollution in China.

### 4.6 Implement environmental protection projects in Poyang Lake Basin agricultural production area

The contamination of soil in the Poyang Lake Plain has worsened over time. In this region, 13.81% of all the soil is moderately contaminated, and the primary contaminants are Cd, Hg, and Ni, with Cd contamination levels rising rapidly. A systematic and comprehensive "mountain, river, and lake" contamination remediation project should be piloted to prevent and remediate the pollution of the Ganjiang River Basin. The commercial extraction of nonferrous metals in the upper reaches must be strictly restricted. In addition, precise pollution prevention and mitigation projects should be strengthened in Nanchang, Shangrao, Xinyu, Jingdezhen, Yingtan, Ganzhou, and Jiujiang, to promote ecofriendly production and ecological management models. The classification, collection, and recycling of household rubbish should be implemented and propagated. Comprehensive rural-environment rehabilitation projects should be continued; water- and fertilizer-saving techniques such as fertigation should be implemented, and a collection and recycling network for used plastic films and pesticide packaging waste should be developed. Additionally, the construction of livestock manure processing facilities should be intensified, for reducing agricultural nonpoint source pollution. A systematic management system for environmental science innovations should also be established.

### 4.7 Implement comprehensive ecosystem remediation project in Bohai Bay

Comprehensive remediation technologies for rivers, wetlands, and shallow seas should be used to construct a "blue barrier" that safeguards the ecosystem of the Bohai Sea. This includes the following. (1) A "three-element" eco-remediation technique for rivers entering the Bohai Sea. Research should be performed on "three-element" cleaning mechanisms and eco-remediation techniques based on the aquatic plants, animals, and microbes of the Bohai Sea's inflows. (2) Eco-remediation techniques for coastal and river-mouth wetlands. Wetland plants and microbes with outstanding water-purifying capabilities that are also salt- and pollutant-resistant should be selected and cultivated for combined eco-remediation techniques. Remediation strategies should also be formulated. (3) Combined shellfish and algae-based eco-remediation techniques for shallow seas. According to the capacity of Bohai Bay, the water-purifying abilities of shellfish and algae species should be utilized in unison via combined shellfish-algae breeding/cultivation techniques; combined shellfish–algae colonies may then be used as an ecological barrier for safeguarding the ecosystem of Bohai Bay. (4) Application and piloting of eco-remediation techniques in the Bohai Sea. Bioremediation techniques should be piloted in key rivers, river mouths, and bays around the Bohai Sea, and a management system should be established for the development of ecofriendly ecological barriers in the Bohai Sea.

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### 4.8 Improve support for synergistic spaceborne, airborne, and ground-based remote-sensing projects for monitoring China's agricultural resource environment

Synergistic spaceborne, airborne, and ground-based remote sensing lies at the cutting edge of global earth observation system developments. The application of unmanned aerial vehicles in agricultural land monitoring and other areas of agriculture should be expanded, along with the layout of ground observation points. Additionally, the construction of ground sensor networks based on the Internet and Internet of Things should be intensified. In this way, it will become possible to dynamically monitor and manage large swathes of the agricultural resource environment on a 24/7 basis in multiple dimensions, under all weather conditions. This will provide a powerful source of data for resource usage optimization and environmental monitoring/management. On this basis, an endeavor should be made to facilitate the monitoring of food-crop and primary agricultural production areas across the globe via remote-sensing technologies.

### 4.9 Implement crop-rotation and land-fallowing projects

In low-yield corn-growing areas such as the Sickle Bay area and the Huang–Huai–Hai region, food crop-growing areas should be replaced with feed-growing areas to grow feeds such as silage corn, medick, oat, and barley, in accordance with local conditions. This will help to satisfy the requirements for developing the animal husbandry industry. In Northeastern China, continuous corn cropping should be replaced with a corn–soybean crop rotation. In the Huang–Huai–Hai region, the double-cropping of wheat and corn should be replaced with the double-cropping of wheat and soybean or corn and soybean. In the areas of Northern China that are suffering from severe groundwater overdrafts, wet farming should be replaced with dry farming, and wheat-growing areas should be reduced by replacing wheat with drought-tolerant crops such as cotton, sunflower, potatoes, and medick. The conversion of decertified, barren, and degraded steep-slope croplands in the area of overlap between farming and animal husbandry regions into grassland should be continued.

### 4.10 Implement reforms in agricultural-product price formation

At present, the pricing of important agricultural products such as food crops does not respond adequately to changes in market supply and demand, which makes it difficult to effect structural adjustments in a timely manner. Therefore, it is necessary to further rationalize food-price subsidies and to progressively reduce the role of food-price subsidies in guaranteeing income. Minimum purchase price policies should be instituted as soon as possible to gradually eliminate the distortions and interference caused by food-price subsidies in the food market. In this way, a mechanism that allows food prices to be determined by market supply and demand can be established. Soybean and corn were removed from China's temporary purchase and storage policy in 2014 and 2016, respectively. Minimum purchase price policies for rice and wheat should be instituted as soon as possible to ensure that their pricing would respond in an adequate manner in different regional markets and periods.