Safeguarding National Food Security by Coordinating Water and Land Resources with Environmental Governance[1]

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The Fifth Plenary Session of the 19th CPC Central Committee called for adherence to a systemic approach to establishing a high-quality development mode that is more efficient, equitable, sustainable and secure. Maintaining resource reserves and mitigating environmental pollution under the premise of food security is a major science issue for China's sustainable development. It is necessary to remove the mechanism obstacles of "each relevant department performing their own functions and constraining each other" and contribute to the building of ecological civilization that covers "all dimensions, all areas and all processes" (Xi, 2019).

Establishing intersectoral and interregional scientific goals that are intrinsically coherent and coordinated is the basis for systemic governance. Taking the relationship between food, water resources and water environment nationwide as an example, a study published in *Nature* (Yu *et al*., 2019) showed that the total nitrogen (TN) concentration of major typical water bodies in China reached or exceeded the level of pollution by 1985; To restore the water quality without reducing food production, it is necessary to nearly double the efficiency of current nitrogen use in farmland, increase the ratio of organic fertilizers returning to fields in urban and rural areas from the current level of less than 40% to more than 86%, and reduce the total demand for fertilizer nitrogen by 55% to 65%, so that the total amount of nitrogen input into China's ecological and environmental systems can be controlled at a safe level. Previous industry policies such as "zero growth in chemical fertilizer use" and "full coverage of sewage treatment" failed to achieve this goal for scientific management (Yu, 2019). At the beginning period for the Second Centenary Goal, it is urgent to adjust the development mode and management mechanism as soon as possible, and meanwhile integrate food security, water and land resources on the one hand, and pollution prevention and control on the other into a unified scientific framework for coordinated governance to achieve the long-term goal of "food security" and "Beautiful China".

I. Issues for water and land resources, environmental governance and national food security

Although ministries of the central government and local governments have made great efforts to

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address water security and food security issues within their respective functions, it is challenging to balance the relationship among arable land resources, water resources, water environment and food security without a systematic, sustainable and coordinated development mode. The challenges to be tackled are as follows.

1. The northward shift of the food production center has led to further escalation of water shortages in the north, therefore top-level coordination is urgently needed.

The irrigated area in northern China has continued to increase in the last four decades. According to statistics (National Bureau of Statistics, 2022), the irrigated area in 2011 expanded by 57% compared with the level back in 1980. After the 2011 Central Water Resources Work Conference, the irrigated area in 2018 has further expanded by 11% compared to 2011. The ratio of grain production between the north and the south increased from 1.0 in 1990 to 1.6 in 2011 and 1.8 in 2018 (Yu, 2019). The continuous shift of the center of grain production to the north has intensified the conflict between agriculture development and water resources as well as the environment (Yu, 2011). Since the implementation of the "strictest water resource management system" in 2012, water use efficiency has been significantly improved. However, it did not fundamentally solve the mismatch between the regional food production and resources supply both in the south and the north, nor change the unsustainable utilization of water resources in northern China.

Agriculture water accounts for 70% to 75% of the water usage in the northern region (Ministry of Water Resources of the People's Republic of China, 1997–2021), which is the dominant reason for the rapid depletion of groundwater reserves and the weakening of the self-purification function of water bodies in the north. Observation data shows that the depth of groundwater in many northern areas have dropped below 50 meters. For example, the depth of groundwater in Hengshui, Hebei Province has dropped below 100 meters (Ministry of Water Resources, 2010–2022). Once groundwater reserves are depleted, grain yields in major production areas in the north might be reduced by over half under extreme drought conditions, and the water supply in the affected areas could be reduced by 2/3 (Yu *et al*., 2018). This will not only threaten China's existing food security, but also endanger social stability.

2. Excessive use of chemical fertilizers, which is increasing eutrophication of water bodies and worsening groundwater pollution, requires comprehensive management.

Studies have shown that the large-scale application of chemical fertilizers has reduced the recirculation rate of organic fertilizers from about 90% in 1980 to below 40% nowadays (Yu *et al*., 2019). The rate of nitrogen discharge into freshwater caused by human activities in China is 14.5 million tons per year (t/a), which is approximately 2.7 times the estimated safe discharge threshold (5.2 million t/a). The nitrogen removal capacity of the national sewage treatment system is only 16% of the national total nitrogen excess discharge (Yu *et al*., 2019). The average total nitrogen concentration from the outlets of the sewage treatment plants (Song *et al*., 2013; Zhao *et al*., 2015) is 7 to 10 times the lower limit of the standard for Class V polluted water quality (2.0 mg/L) (State Environmental Protection Administration and State Administration of Quality Supervision, Inspection and Quarantine, 2002). With limited capacity for nitrogen removal and the current environmental policies, pollutant discharges are driven to transfer to environments where monitoring is absent or difficult to implement. In particular, the farmland leaching, farming manure and domestic sewage in the northern plains are mostly discharged to groundwater environments that are difficult to regulate. Monitoring data from the Ministry of Water Resources in 2016 showed that 80.3% of shallow groundwater had reached or exceeded the threshold for Class IV water quality standards (Ministry of Water Resources of the People's Republic of China, 2016). For example, in October 2020, the State's media CCTV reported an outbreak of groundwater pollution crisis in Pingyi, Shandong (Shandong Radio and Television Station, 2020), manifesting an urgent need for systematic and effective measures to cut off various groundwater pollution chains.

3. Insufficient policy synergies among authorities in agriculture, water resources, and ecology and environment, which need to be integrated and harmonized.

Different objectives of governmental departments lead to difficulties in harmonizing sectoral policies during local implementation. For example, the authorities in agriculture, as well as health and wellness, have worked over the last four decades to accelerate

the development of the breeding industry and promote the rationalization of dietary structure. However, this has also led to serious aquaculture pollution problems. In order to reduce the impact of breeding pollution, the environmental protection authorities have carried out large-scale law enforcement in areas where livestock and poultry breeding is prohibited and closed a large number of farms. Such moves are believed to be contributing to the surge in pork prices since 2019. Although the State Council later asked local governments to withdraw unreasonable "prohibition" regulations, it did not fundamentally resolve the contradictions between agricultural production and environmental protection. This highlights the lack of coordination in policy formulation among the ministries of the central government, and the absence of cross-departmental systematic and scientific review before the policy is issued, which has negative implications on the appropriateness, continuity and authority of national policies.

II. Countermeasures and suggestions

Traditional circular agriculture of China over thousands of years has been regarded by the world as a model for pollution-free and sustainable agricultural development. Trends in agricultural production patterns and environmental changes over the past 40 years have shown that simply copying Western systems of technology and standards cannot address food security and environmental protection simultaneously under the pressures of population and resources in China. Research results on nitrogen pollution, water resources and food security (Yu *et al*., 2019) show that the current science and technology has enabled cross-industry and interdisciplinary quantitative research on meteorology, water resources, agriculture, natural resources, ecological environment, population, and urban and rural construction. Such research may provide scientific support for China to explore a path for sustainable development that is consistent with its national realities. To this end, the following suggestions are proposed.

1. Establish a provincial agricultural production responsibility system to thoroughly ease the bottleneck of water shortage in northern regions

Evaluate the agricultural production potential and environmental safety thresholds of each provincial region based on production conditions such as climate, water resources, and arable land, allocate the agricultural production tasks of each province in a quantifiable manner (Yu, 2019), and ensure that the overall national grain output rises steadily. Scale up the goals of agricultural production in relatively water-rich and economically developed regions, thus allowing these regions to reform their agricultural management modes and develop new agricultural production technologies, so as to improve the efficiency of water resource utilization, reduce production costs, and decrease the proportion of abandoned arable land. Increase water transfer volume from the middle and eastern routes of the South-to-North Water Diversion Project to areas with overexploited groundwater, and promote the construction of supporting facilities for water-saving irrigation and drinking water for humans and livestock. Accelerate the construction of the western route of the South-to-North Water Diversion Project, and tap the agricultural production potential of arid and semi-arid areas. Explore models for "sponge cities" and flood exploitation, gradually restore groundwater reserves and surface runoff in northern regions, enhance the self-purification capacity of water bodies, and reduce drought risks. Continue to promote water-saving measures, scale down agricultural production tasks in regions with water shortage and black soil, increase ecological water supply, and completely solve problems caused by the northward shift of the grain production bases and excessive consumption of groundwater in the north.

2. Comprehensively rebuild a system for returning natural fertilizers to the field in urban and rural areas, develop efficient utilization models of fermented manure mixed with water, and eliminate eutrophication in the environment.

Change the current environmental protection approach focused on "pollution control" and return to the traditional sustainable production model "returning the fermented manure mixed with water to the fields". Establish connections between urban-rural construction and agricultural production, link urban and rural domestic sewage discharge networks and treatment systems to the farmland irrigation, and separate it from industrial wastewater; after eliminating the risks of soil pollution and viral infection, return the fermented manure mixed with water to fields (Yu *et al*., 2019). Reduce the economic burden on breeding owners and have society at

large jointly bear the costs of recycling manure to fields. Establish a supervision system for breeding manure discharge, and conduct systematic management of land-related supporting facilities, facility construction, benefit distribution, fertilization technology, professionalized services, and strengthened supervision, to completely eliminate direct discharge of manure. On the basis of the rural household contract responsibility system, establish a large-scale and post-based rural service system (Yu, 2019), to provide professionalized services for improving the utilization efficiency of fermented manure mixed with water, promoting the recycling of urban and rural organic fertilizer, increasing the organic carbon storage in cultivated land, and restoring farming of abandoned land. Establish a long-term mechanism to increase rural employment and consolidate the results of poverty alleviation.

3. Establish a unified coordination and consultation mechanism among relevant governmental ministries and departments, and jointly formulate national environmental and food security plans

It is recommended to establish a cross-industry and interdisciplinary scientific and technological steering committee and working groups as soon as possible. Under a unified scientific framework, formulate national environmental and food security plans that can promote coordinated actions among ministries and regions, and clarify quantitative management goals and action plans for each department and region. In view of the current problem of fragmented management by sectors, establish coordination mechanisms for routine business between ministries, and implement coordinated actions between departments and regions in aspects like tasks, funding, and performance assessment. Recalculate and coordinate the funds dispersed across various sectors such as agriculture, water conservancy, urban-rural construction, natural resources, ecological environment, chemical industry, and food safety; incorporate the cost of water and soil environmental protection and restoration into the economic accounting system, and allow farmers to become a major player in agricultural production, environmental protection and ecological restoration (Yu, 2019).

Under the guidance of the "high-quality development" philosophy, China has the capability to comprehensively solve the major integrated issues such as farmland quality, water and land resources and environment, as well as food security, and can set an example for addressing global population, food and environmental sustainability challenges facing humanity in the 21st century.

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