Bohai Granary: Harnessing the Saline-Alkali Lands

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Abstract: Agriculture forms the backbone of a nation, and food security is essential for social stability and sustainable economic growth. In China, ensuring adequate food production is not only critical for national well-being but also a strategic priority for maintaining self-sufficiency. To enhance food security, two key approaches are increasing yields from the existing agricultural lands and improving the productivity of low- and medium-yield farmland. One of China's major underutilized resources is its extensive saline-alkali lands, which, despite historically low productivity due to poor soil conditions and scarce freshwater resources, hold immense potential for boosting grain output. Recognizing this, the Chinese Academy of Sciences, in collaboration with the Chinese Ministry of Science and Technology (MOST), initiated the "Bohai Granary Scientific and Technological Demonstration Project" (Bohai Granary Project for short) in partnership with three provinces and one municipality—Hebei, Shandong, Liaoning, and Tianjin. This project represents a landmark effort to rehabilitate saline-alkali lands and transform them into highly productive grain-producing regions, thereby contributing significantly to China's food security strategy. In this article, the author revisits the key milestones, technological breakthroughs, and outlook on the future potential of this project.

Keywords: food security, saline-alkali land, Bohai Granary Project, soil improvement, agricultural innovation

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In 2000, China's agricultural consumption outpaced production, leading to a significant grain shortage. By 2003, the country faced a shortfall of 61.23 billion kilograms of grain, posing a serious threat to national food security. In response, the Chinese government implemented a series of agricultural policies, and in 2009, introduced a national plan aimed at increasing grain production by 50 billion kilograms by 2020. While high-yield regions had reached almost their maximum potential, vast opportunities lay in low- and medium-yield areas.

One of such areas is the coastal plain surrounding the Bohai Sea, which includes parts of Hebei, Shandong, Liaoning, and Tianjin. These regions suffer from severe soil salinization and limited freshwater resources. However, the 50 million mu (approximately 3.33 million hectares) of low- and medium-yield fields in this region present immense potential for boosting grain production.

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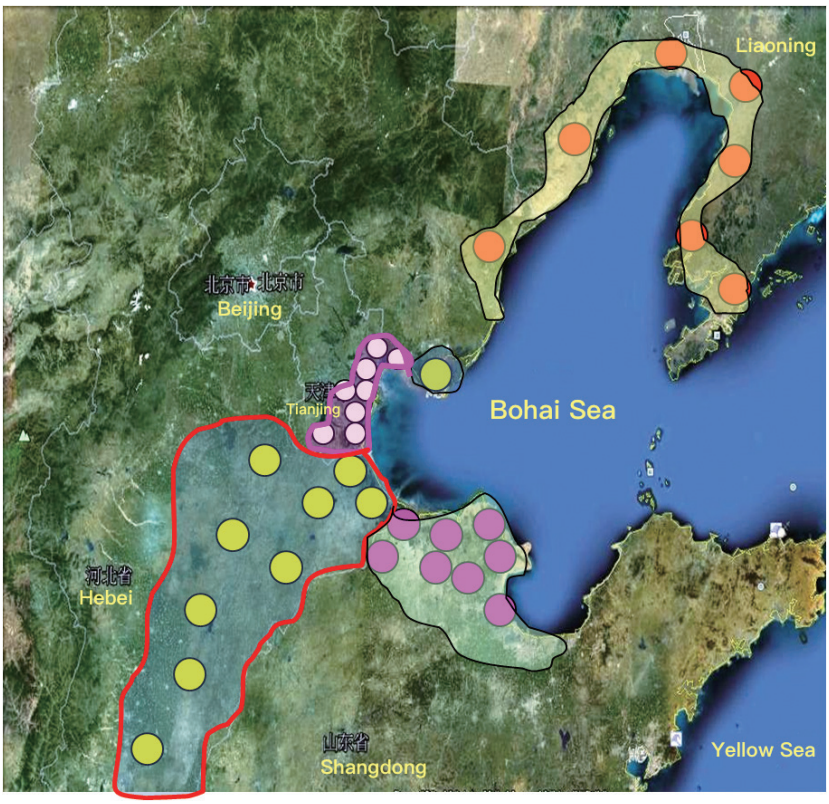


Graphic: LIU Xiaojing

The location of Bohai granary.

The Birth of the Bohai Granary Project

Recognizing the potential of these lands, LI Zhensheng, a professor at the Institute of Genetics and Developmental Biology (IGDB) under the Chinese Academy of Sciences (CAS) and a CAS Member, conducted extensive research. His analysis of China's needs for higher yields and the opportunities in the Bohai Sea region led to the strategic proposal of the Bohai Granary initiative. The project focuses on improving saline-alkali lands to increase grain output, from a national food security perspective.

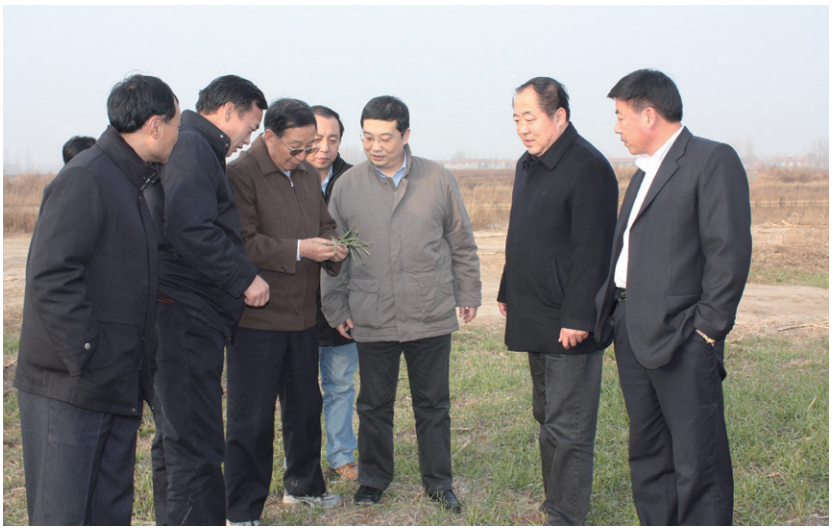
The Bohai Granary Project aims to achieve breakthroughs in key areas such as developing salt-tolerant crop varieties, safely using brackish water for irrigation, and reclaiming saline-alkali lands. By integrating these advancements, the project seeks to establish region-specific models for increasing grain production and demonstrating large-scale agricultural innovation in collaboration with local governments and new agricultural entities.

By 2020, the Bohai Granary set the goal of increasing grain production by 5 billion kilograms: 2.4 billion kilograms from 40 million mu (about 2.67 million hectares) of low- and medium-yield farmland, 2.1 billion kilograms from 3 million mu (about 200,000 hectares) of cotton fields, and 0.5 billion kilograms from 1 million mu (about 66,700 hectares) of reclaimed saline-alkali land.

Initial Success and Nationwide Expansion

CAS played a leading role in the project's initial success, conducting experimental demonstrations of salt-tolerant wheat, brackish water irrigation, and saline-alkali land reclamation in key regions such as Cangzhou (Hebei) and Binzhou (Shandong). Building on these achievements, in May 2011, CAS hosted the Bohai Granary and Resource-Efficient Agricultural Development Summit in Yucheng, Shandong, where it gained the local stakeholders' support.

In July 2011, Academician LI Zhensheng and colleagues published a seminal article in the *Bulletin of Chinese Academy of Sciences* (Chinese version) titled "*The Scientific Basis for Building the Bohai Granary: Needs, Potential, and Pathways*," which outlined the project's feasibility. By June 2012, CAS held field observation



Graphic: WANG Lizhong

On December 2, 2009, Academician LI Zhensheng (third from left) inspects the seedling growth of salt-tolerant wheat variety *Xiaoyan 81* in the saline-alkali fields of Nanpi, Hebei.

meetings and seminars in Cangzhou and Binzhou to promote grain production and improve saline-alkali lands, advancing the project's formal approval process.

In October 2012, the "Bohai Granary Scientific and Technological Demonstration Project" received the official approval from the MOST, and by April 2013, it was officially launched. This project is strategically significant in ensuring national food security and modernizing agricultural development in the region.

Graphic: LIU Xiaojing

On May 17 and 18, 2011, the Chinese Academy of Sciences organized the Bohai Granary Strategic Summit Forum in Yucheng, Shandong.

Key Technological Breakthroughs

Establishing a Salt-Tolerant Crop Breeding System

The CAS Institute of Genetics and Developmental Biology (IGDB) has pioneered a breeding system for salt-tolerant crops, focusing on wheat. Utilizing years of research findings in distant hybridization and chromosome engineering, IGDB developed a series of salt-tolerant wheat varieties. By cross-breeding wild wheatgrass from the salt-alkali regions of Salt Lake City, USA, with regular wheat, scientists successfully transferred salt-tolerance genes into wheat using advanced chromosome engineering techniques. This led to the creation of several salt-tolerant wheat strains, such as *Xiaoyan 81*, *Xiaoyan 60*, and *Xiaoyan 155*. These varieties thrive in soils with a 0.3% salt content, yielding 350–400 kg per mu (approximately 5,250–6,000 kg per hectare), which represents a 5–10% increase compared to conventional wheat varieties.

Developing a Brackish Water Irrigation System

The Bohai Sea region suffers from extreme freshwater shortages, with water resources per capita at only 1/12 of the national

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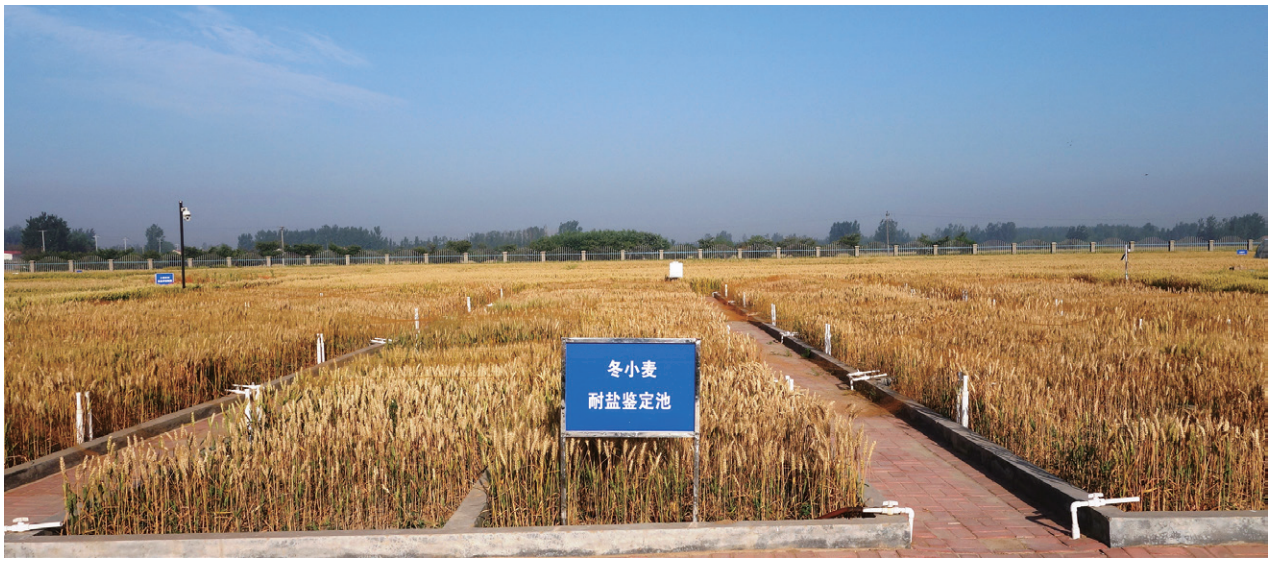
On June 5 and 6, 2012, CAS organized a field observation meeting for low- and medium-yield saline-alkali land (upper) and a Bohai Granary symposium (bottom).



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Salt-tolerance testing patches.

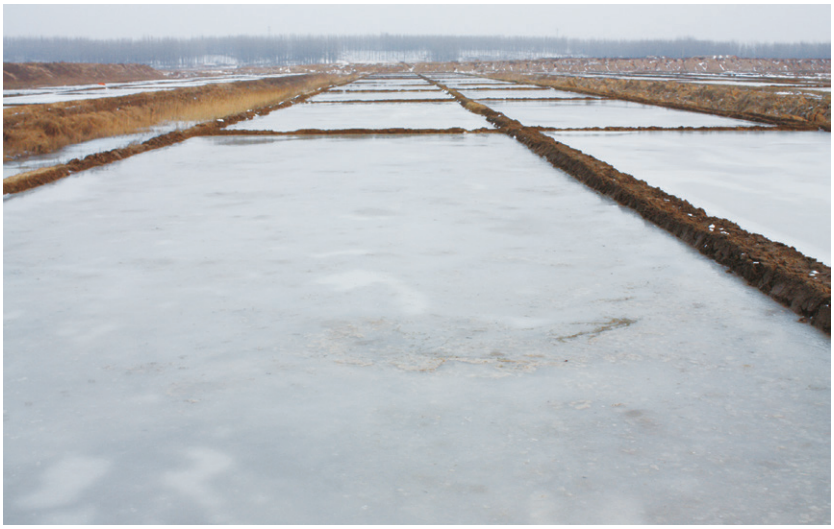
average. However, the area has abundant brackish water resources—over 5 billion cubic meters of water with salinity below 5 g/L can be tapped annually. The CAS Agricultural Resources Research Center, part of IGDB, found that as crop straw return and mechanization techniques improve, the soil's organic matter content increases. This enrichment helps maintain soil structure under brackish water irrigation, enhances salt leaching, and improves crop salt tolerance.

When soil organic matter increases from less than 1.0g/100g to over 1.5g/100g, the brackish water irrigation threshold rises from 3 g/L to 5 g/L. Using brackish water (less than 5 g/L) during wheat's jointing stage increased yields by 20–30% compared to rain-fed farming, without reducing yields compared to freshwater irrigation. Furthermore, monsoon rains in the summer prevent salt buildup in the topsoil, making this a sustainable irrigation method. A brackish water irrigation regime was developed, involving winter water storage, spring irrigation for drought resistance and salt suppression, and emergency summer irrigation. This technique, applied to the wheat-maize double cropping system, saved 100 mm of freshwater and increased grain yields by 100 kg per mu (approximately 1,500 kg per hectare).

Overcoming Challenges in Saline-Alkali Land Reclamation

The coastal saline-alkali land in the Bohai region is characterized by high soil salt content, shallow saline groundwater, and a scarcity of freshwater for leaching salts. IGDB's Agricultural Resources Research Center developed a freezing saline water irrigation technique to reclaim heavy saline soil in winter that uses saline water with a salinity of less than 15 g/L. During winter, the saline water freezes on the soil surface, and as it melts in spring, the initial melted high salinity water infiltrates firstly, and then melted low salinity (or even freshwater) infiltrates later and carries the leached salts out of the root zones, reducing salt levels in the topsoil to less than 0.3%, compared to 1.0% in untreated fields. Cotton yields in these reclaimed

A freezing saline water irrigation technique for reclaiming heavy saline soil in winter.



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areas exceeded 200 kg per mu (approximately 3,000 kg per hectare) in the first year.

The team also developed a straw deep-burial technique for wheat production on moderately saline-alkali lands. By burying crop residues in the fall, this method helps maintain a low-salt soil environment, allowing winter wheat yields to increase 2 to 3 times. Additionally, the CAS Institute of Geographic Sciences and Natural Resources Research developed a microbial organic fertilizer that improves soil structure and fertility, reducing soil salinity from 0.4% to below 0.2%. Wheat and maize yields increased by over 40%.

Graphic: LIU Xiaojing

Straw deep-burial technique (upper) leads to improved grain production (bottom).

Project Implementation and Achievements

The Bohai Granary Project spans 50 million mu (approximately 3.35 million hectares) across three provinces and one municipality: Hebei, Shandong, Liaoning, and Tianjin. With the involvement of 33 institutions and over 500 scientists, the project demonstrates a massive collaborative effort. CAS leads the development of key technologies, while local agricultural research institutions, agricultural technology extension departments, and enterprises handle technology integration, demonstration, and transfer.

To ensure the effective implementation of the Bohai Granary Project, a leadership group was established, consisting of officials from MOST, CAS, and leaders from the local governments involved. This group was responsible for overseeing the project's top-level design and coordination. Each of the regions in the demonstration area set up their own implementation teams, led by provincial governors and involving heads of departments such as science, agriculture, water resources, and finance etc. These teams managed the allocation of personnel and funding for the project.

At the technical level, a chief scientist system was introduced to guide the overall project design and ensure technical accuracy. Each demonstration region appointed a regional chief scientist responsible for constructing and promoting the local demonstration zones. This collaborative model, led by CAS and supported by the Ministry of Science and Technology, along with local governments and industry, created a seamless integration of research, technology deployment, and result dissemination.

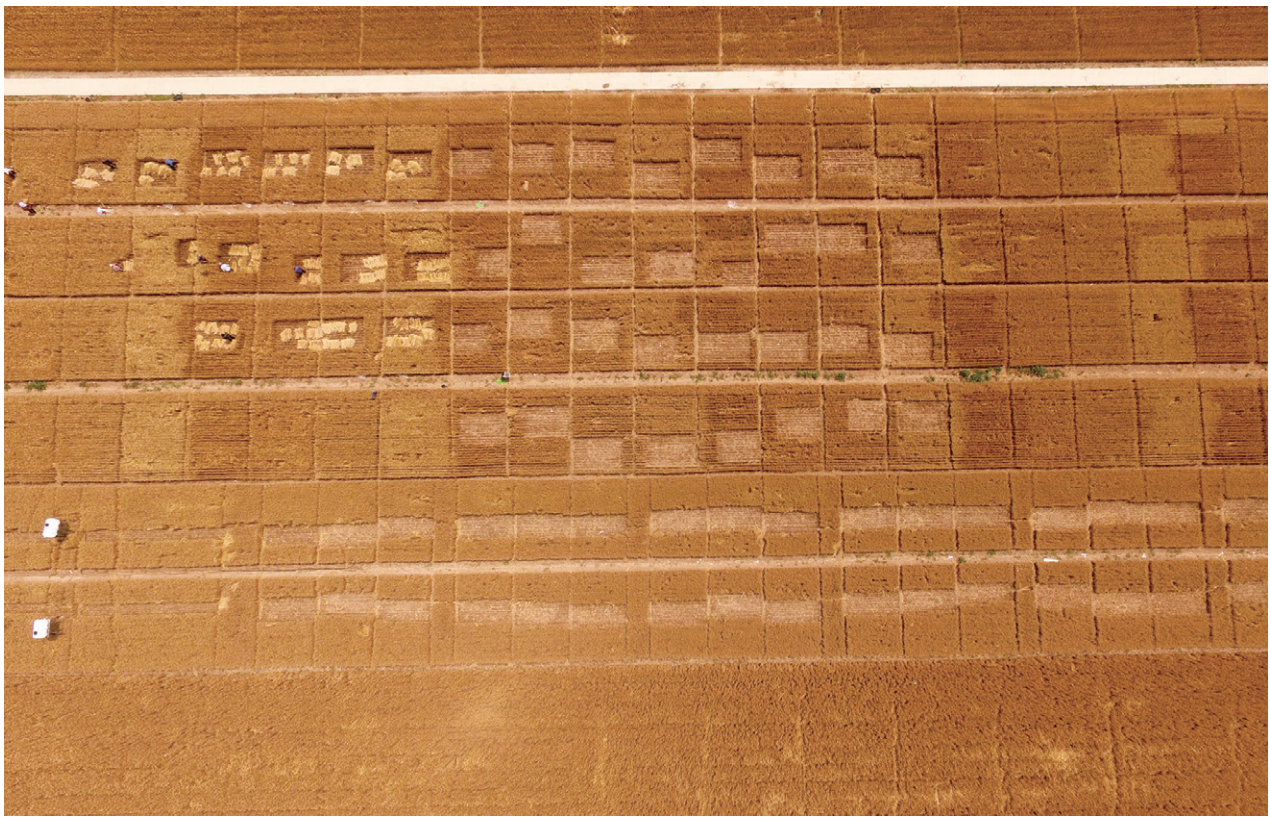
During the project's execution, barriers to technological adoption by small-scale farmers were overcome by focusing on large-scale demonstrations led by enterprises and agricultural cooperatives. Modern technology dissemination methods were used, and comprehensive training and guidance were provided to ensure the project's success.

In Hebei Province, a plan was developed with a budget of 200 million yuan to support the demonstration projects. The strategy emphasized progressively larger demonstration plots to showcase results, starting with small experimental fields and expanding to larger areas for broader application. This approach aimed to drive productivity and efficiency improvements, following a government-led, sci-

Graphic: WANG Lizhong

An aerial view of the CAS Haixing coastal saline-alkali land efficient utilization demonstration base in Hebei province.

It's time to measure the wheat yield amidst a shimmering sea of golden grids.



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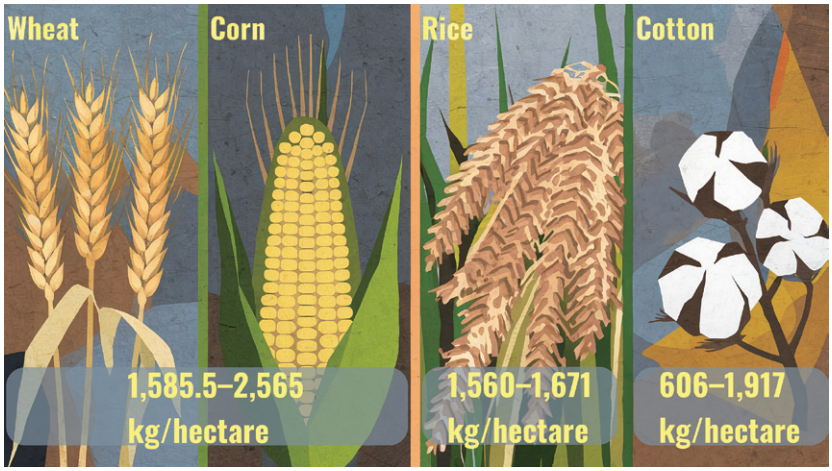

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Yield increase in the demonstration zones of the Baohai Granary Project.

ence-driven approach with cooperatives playing a central role.

In Shandong, the approach leveraged the province's advantages of strong economic foundation and rapidly growing enterprises to create a model led by government guidance and scientific expertise, with enterprises playing a key role. Government funding was used primarily to encourage enterprise participation, linking technological demonstrations closely with business operations to promote large-scale farming and increased productivity.

In Liaoning, universities played a pivotal role in training professional farmers, further improving the quality of project implementation.

In Tianjin, the agricultural technology extension stations played a crucial role by closely aligning the project with ongoing agricultural extension programs, focusing on large-scale farmers to implement the project.

The project has implemented 23 innovative techniques, such as brackish water irrigation, micro-irrigation and saline-alkali land reclamation etc., to boost grain production and water efficiency.

A total of 228 demonstration and training sessions have been held, training 69,000 farmers and technical personnel, while 240,000 technical guides have been distributed. In the provinces of Hebei, Shandong, Liaoning, and the municipality of Tianjin, 79 large-scale demonstration zones with each over 5,000 mu (333 hectares) have been established.

These initiatives have led to significant gains in the demonstration zones: wheat and corn yields increased by 105.7–171 kg per mu (approximately 1,585.5–2,565 kg per hectare), and rice yields by 104.0–111.4 kg per mu (approximately 1,560–1,671 kg per hectare). Apart from grains, cotton yields have also been increased by 40.4–127.8 kg per mu (approximately 606–1,917 kg per hectare). Improvements to saline-alkali soils resulted in a 50% reduction in soil salinity, while the return of crop straw to the soil boosted organic matter levels from 1.1–1.3 g/100g to 1.5–1.8 g/100g.

By 2017, the project had expanded to 95 counties, covering 31.1 million mu (about 2.1 million hectares) of low-yield farmland. Yields increased by an average of 173 kg per mu (approximately 2595 kg per hectare), producing an additional 3.46 billion kg of grain, with economic benefits of 6.47 billion yuan and water savings of 1.13 billion cubic meters. Between 2013 and 2017, a total of 80.17 million mu (about 5.3 million hectares) of farmlands were improved, including 5.47 million mu (about 364,000 hectares) of cotton fields converted to grain production, and 2.9 million mu (about 193,000 hectares) of saline-alkali land reclaimed, resulting in a total grain increase of 10.47 billion kg, economic benefits of 18.65 billion yuan, and water savings of 4.35 billion cubic meters.

Outlook

China is making the sustainable use of saline-alkali lands a priority to help secure its food supply. The Bohai Granary Project stands as a model for improving food security, expanding arable land, and enhancing ecological balance—not just within China, but as an example for other countries facing similar challenges. Led by CAS, the project brings together cutting-edge research, technologies, and systems to boost national food production and promote global agricultural sustainability.

At the heart of the project is the strategic matching of crops to the unique conditions of saline-alkali land, unlocking the potential of these underutilized areas while maintaining environmental integrity.

The path to success in this endeavor requires persistence, collaboration, and multidisciplinary research. By transforming previously unproductive land into fertile agricultural regions, China is making strides toward strengthening both domestic and global food security. This approach underscores the broader benefits of sustainable farming practices—not only restoring the land but also supporting the well-being of people and ecosystems worldwide.