Prospects and Analysis of New Strategies for Agricultural Industrialization with Chinese Characteristics

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Date: 2026-03-18T23:11:23+00:00

Abstract

Guided by the "Great Resource Outlook," this study elucidates a new strategy for agricultural industrialization with Chinese characteristics, utilizing new industrial biomanufacturing as the technological engine. This approach aims to simultaneously satisfy national food security strategic goals and resolve the "food vs. fuel/industry" dilemma regarding biomanufacturing raw materials.

We propose a three-pronged solution of "broadening sources, increasing efficiency, and substitution." Specifically, the "grain-from-straw" technology will be used to broaden resource utilization and efficiently convert 600 million tons of straw. This will be achieved without altering the planting structure of food crops, thereby revolutionizing the sources of energy and protein components in the non-ruminant feed industry and reshaping the raw material sources of the industrial biomanufacturing sector with feed corn.

Furthermore, we suggest constructing a resource-matching system for a unified national market of agriculture and industry. This involves utilizing innovative enterprises as the main entities to conduct innovation demonstrations for non-grain biomass utilization scenarios, exploring starch quota trading systems and market access pathways for synthetic biology. By applying industrial thinking, technology, and management models, we aim to enhance the efficiency, resilience, sustainability, and economic viability of the "Second Agriculture," ultimately achieving the transformation of agriculture into industry.

Full Text

Prospects for a New Strategy of Agricultural Industrialization with Chinese Characteristics

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Abstract

Guided by the "Comprehensive Resource Perspective (CRP)," this study aims to support the national strategic goal of the "All-Encompassing Approach to Food"by proposing a new strategy for agricultural industrialization with Chinese characteristics. This strategy is powered by a new industrial biomanufacturing platform designed to sustainably provide high-quality food sources, such as protein and energy for both humans and animals. By enabling systemic bioresource allocation, the strategy fosters synergy between agriculture and industry, replacing or supplementing low-efficiency, land-based cultivation with high-efficiency, factory-based industrial biomanufacturing. This approach could reshape China' s industrial biomanufacturing sector and boost its output value by three-to-five times.

The strategy addresses three major challenges simultaneously: inefficient bioresource matching, heavy dependence on soybean imports, and feedstock constraints for industrial biomanufacturing. To address these, we propose a "Three-Axe" approach: diversifying resources (using non-food biomass), enhancing efficiency (replacing soybean protein with microbial amino acids), and utilizing new feedstock substitutes for biomanufacturing. Specifically, leveraging China' s strengths in fermentation, we pioneer a "Second Agriculture" through paradigm-shifting "straw-to-food/feed"technologies. It is estimated that the high-efficiency utilization of 600 million tons of agricultural residues (such as straw) is equivalent to adding 87 million hectares of farmland. This approach can disruptively change energy and protein sourcing in the feed industry and reshape the feedstock landscape of the biomanufacturing sector.

Furthermore, it is crucial to build a resource allocation system that integrates agriculture and industry into a unified market. This includes innovative demonstrations for non-food biomass utilization led by enterprises and a starch quota-trading system. These measures will optimize the "agricultural residue-grain-feed-industrial feedstock" allocation, promote biomanufacturing as a new economic growth point, and enhance the efficiency, resilience, and sustainability of

"Second Agriculture," facilitating the transition toward full agricultural industrialization.

Keywords

agricultural industrialization; food security; straw-based food production; innovative demonstration; starch quota-trading system

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Food security is a matter of vital national importance, and agricultural industrialization is an essential path toward ensuring it. Traditional agricultural industrialization focuses on applying industrial mindsets, technologies, and management models to improve land productivity and resource utilization. With the introduction of the "Greater Food Outlook," China's concept of food security has shifted from "having enough to eat" to "eating well and healthily," emphasizing a diversified supply system integrating agriculture, forestry, animal husbandry, and fisheries.

This paper proposes a new strategy for agricultural industrialization based on a "Greater Resource Outlook." This strategy emphasizes systemic resource allocation to achieve mutual support between agricultural and industrial resources. For example, it advocates using non-grain biomass to produce high-quality nutrients—such as feed-grade amino acids, proteins, and starch—while converting traditional agricultural products like corn into industrial raw materials such as bio-based materials.

New biomanufacturing technologies ensure the technical feasibility of this strategy. Breakthroughs in synthetic biology and engineering biology have overcome the limitations of single-pathway raw materials. These advances enable the flexible selection of first-generation (starch/glucose), second-generation (non-grain biomass), or third-generation (carbon dioxide) raw materials. By breaking the boundaries between agriculture and industry, it is possible to achieve full-chain optimization of "raw material-process-product" in terms of cost and sustainability.

1. Three Major Challenges of the New Agricultural Industrialization Strategy

1.1 Resource Matching Challenges: Barriers to Synergy between Agriculture and Industry

Historically, major climate changes have driven fundamental transformations in human survival. Today, global warming and population growth pose unprecedented pressure on the global food supply. China faces internal pressures from land constraints and external instability in global supply chains. While China' s staple self-sufficiency is nearly 99%, the imported grain, oil, and meat required to "eat well" are equivalent to the output of 900 million *mu* of arable land.

Currently, it is difficult to achieve efficient connectivity between industrial and agricultural resources. The agricultural sector focuses on staple grain security and yield, while the industrial sector lacks policy tools to intervene in agricultural structures. Establishing a system capable of providing the output equivalent of 2.9 billion *mu* of arable land is the primary challenge.

1.2 The "Soybean Challenge" : Dependence on Traditional Protein Resources

China' s soybean imports reached 105 million tons by 2024, while domestic production was only 20.6 million tons. The heavy dependence of animal feed on imported soybeans is the most vulnerable link in the food security chain. Although the "Three-Year Action Plan for Soybean Meal Reduction" aims to reduce this dependence using synthetic biology to produce amino acids, the raw materials for these amino acids are still grain-based. Without a sustainable non-grain foundation, this strategy remains limited.

1.3 Challenges in Biomanufacturing Feedstocks: Commercialization Bottlenecks

Bulk chemicals require low-cost resources. For bio-based chemicals, raw material costs account for a significant portion of manufacturing costs. While first-generation raw materials (corn starch) are efficient, they compete with food supplies. Second-generation materials (straw) are complex and expensive to process, with biomass glucose prices often double those of starch glucose. Third-generation materials (CO_2) are still in the proof-of-concept stage. Securing high-purity, low-cost, and sustainable feedstocks is critical for a large-scale bioeconomy.

2. Implementation Paths for the New Strategy

Traditional agriculture utilizes land to generate energy (starch) and protein. However, these pathways are constrained by natural resources. Biomanufacturing can utilize biocatalysts to transform the "energy" generated by various sectors into food, feed, and industrial products. By integrating "straw-to-grain" technologies with existing fermentation industries, a three-pronged strategy of "expanding resources, increasing efficiency, and implementing substitution" can be executed.

2.1 "Grain from Stalks" to Resolve the Soybean Challenge

In 2024, China' s industrial feed consumption reached 312 million tons, with pig and poultry feed accounting for 87%. The quality of protein feed depends on its amino acid composition. Utilizing synthetic biology to produce feed-grade amino acids is more efficient than direct microbial protein production. Swine farming practices show that substituting soybean meal with synthetic amino acids can reduce soybean meal content in feed from 20% to below 5%.

Furthermore, land productivity for the corn-to-amino acid route is more than four times that of traditional soybean cultivation. One *mu* of land yields 47 kg of soybean protein, whereas the same area planted with corn can produce 198 kg of amino acids via fermentation. If 439 million *mu* of corn acreage were converted to industrial amino acid production, it would be equivalent to adding 1.3 billion *mu* of new arable land.

2.2 Expanding Non-Grain Biomass Sources

Crop stalks are the world' s largest renewable organic carbon resource. New "stalk-to-food" technologies utilize *in vitro* Biotransformation (ivBT) to convert cellulose into starch and glucose. Recent breakthroughs have achieved a high-efficiency conversion of 0.93 grams of starch from 1 gram of cellulose. Converting 600 million tons of straw into 350 million tons of straw-derived sugar could fully satisfy the energy and protein feed requirements of non-ruminant animals, effectively adding 1.3 billion *mu* of virtual cultivated land.

2.3 Substituting Feed Grain for Industrial Grain

By using agricultural stalks as raw materials for feed, 200 million tons of corn traditionally used for feed could be repurposed as industrial grain. This would allow the biomanufacturing industry to produce high-value food, pharmaceuticals, and materials without competing with human food supplies. This shift is expected to generate at least 2 trillion RMB in additional industrial output value.

2.4 Matching Resources: Application Scenario Innovation

To implement these strategies, "Food-Biomass Integrated Application Scenario Innovation Demonstration Zones" should be established. A central tool would be a "Starch Quota Trading System." The government would issue "starch quotas" to enterprises based on the grain-equivalent savings their technologies achieve. Grain-based enterprises would then purchase these quotas, creating a market-driven incentive for technological innovation.

3. Conclusion

The new strategy for agricultural industrialization with Chinese characteristics represents a deepening of the "Greater Food Outlook." By moving from a zero-sum game mindset to a "Greater Resource Outlook," China can secure its food supply while cultivating globally competitive biomanufacturing clusters. This approach builds the foundation for "new quality productive forces," ensuring national security and driving economic growth.

Note: Figure translations are in progress. See original paper for figures.