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Demand, Challenges, and Optimization Paths for the Development of the Grain Industry in China's Mountainous Regions

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Abstract: ***Ensuring national food security is crucial for economic development, social stability, and national security. In China, food security still faces significant challenges and regional imbalances, and promoting the high-quality development of the grain industry in mountainous regions is not only essential for national food security but also a vital path for high-quality agricultural development and comprehensive rural revitalization in these areas. This holds unique value and practical significance for China's food security. The development of the grain industry in China's mountainous regions is constrained by factors such as resource limitations, fragile ecological environments, and inadequate infrastructure; it faces resource, organizational, market, and policy challenges. There is a need to emphasize a development orientation towards "green and superior" and "small but refined," adopting targeted optimization paths such as enhancing appropriately scaled development, emphasizing composite development, strengthening green leadership, optimizing policy support, and reinforcing interest linkages.***

Keywords: Food security, Grain industry, Mountain agriculture, China**.**

1. Introduction

Food security is fundamentally connected to national well-being and livelihoods; it is not only a foundation for economic development and social stability but also a fundamental requirement for building a modern socialist country and achieving rejuvenation in China.

Despite consecutive years of bumper harvests in China, with high self-sufficiency rates in grains and staple foods contributing positively to global food markets and food security, the realities of a large population, limited land, water scarcity, and increasingly constrained ecological resources along with a complex and volatile international situation mean that long-term food supply and demand remain in a delicate balance. Furthermore, with population growth and the upgrading of consumption structures, structural contradictions in food supply and demand have become increasingly prominent. Given the generally limited agricultural resources, making full use of the potential to expand the supply capacity of food and agricultural products and enrich the diversity of food supply is of great significance for ensuring food security and meeting the diversified and segmented food needs of the population.

China's vast territory and diverse topography are fundamental to its national conditions; China has mountains, plains, hills, basins, and other complex terrain. According to the first national geographical conditions census announcement (2017), mountains and hills account for 43.65% and 20.39% of the country's land areas, respectively. Overall, compared with the flat terrain and fertile soil of the plains, the complex terrain, underdeveloped economy, and significant limitations facing the development of large-scale and mechanized agriculture in mountainous regions result in relatively low grain production efficiency. However, through improvements in production conditions and reasonable industrial layouts, mountainous areas also offer conditions for the high-quality development of the grain industry. In addition, the diverse microclimates and differentiated soil conditions in mountainous areas provide a foundation for developing specialized and premium grain products. Therefore, despite its challenges, promoting the development of the grain industry these areas can enhance China's overall grain production capacity and promote food security while meeting the segmented, quality, and diversified consumption demands for grain products.

Overall, extensive research has been conducted on food security in China's mountainous regions, with strong theoretical significance and practical value; however, there has been little focus on the development paths of the grain industry, with research typically focusing on individual aspects rather than taking a system-based approach. Indeed, few studies have proposed targeted countermeasures based on the unique challenges and individual conflicts of the grain industry in mountainous regions. Therefore, this study systematically analyses and discusses the various challenges that need to be addressed and resolved in the current and future development of the grain industry in these regions based on a thorough analysis of the development demands. Based on these findings, suggestions for developing the grain industry in mountainous regions and improving policy support are proposed.

2. A Realistic Demand for the Grain Industry in Mountainous Regions

2.1 China's Food Security Faces Significant Challenges

In recent years, China has adhered to the principles of "storing grain on land and storing grain in technology," successfully promoting a continuous increase in domestic grain production by stabilizing and expanding arable land area and improving agricultural technology. However, with the acceleration of population growth, urbanization, and industrialization, the demand for grain continues to increase. As the level of social

and economic development has gradually improved, the dietary structure of the Chinese population has undergone significant changes, and the problem of a food supply and demand mismatch has gradually become prominent. At the same time, an improvement in grain self-sufficiency has been achieved at the expense of a decline in arable land quality, which affects the sustainability goals of food security and further highlights the significant constraints on resources.

2.2 Regional Imbalance Contradictions Remain Prominent

Currently, China's food supply and demand are in an overall delicate balance, with significant and increasingly prominent structural contradictions in terms of variety and quality. Additionally, there is a significant and intensifying regional imbalance between food supply and demand. From the perspective of major grain-producing areas, the southeast coastal areas have become food-importing regions, with an increasing number of regions in the western areas requiring grain imports. Changes in regional grain supply and demand patterns are the main factors forming the dislocation between major production and consumption areas.

From another perspective, China's grain supply and demand imbalance is evident not only between administrative regions but also between geographic regions. For example, plains have natural geographical advantages over mountainous areas, with richer soil resources suitable for growing various crops, abundant water resources, dense rivers and lakes, and the relative ease of construction and maintenance of large-scale irrigation systems, which contribute to higher agricultural output and crop stability. Consequently, in recent years, China's grain production has continued to shift towards the northern plains, with the proportion of the national total output increasing from 36.7% in 2000 to 63.3% in 2020, indicating that the plains continue to play a major role in grain supply. However, mountainous counties account for more than two-thirds of China's total land area, with 34.62% of the nation's arable land, but less than 30% of the national total grain supply, indicating an insufficient productivity layout and low production efficiency that does not match the vast land area nor meet the requirements for building a higher-level, higher-quality, more efficient, and more sustainable food security system

3. Special Characteristics of Grain Industry Development in Mountainous Regions

3.1 Special Natural Conditions

1) Significant Resource Constraints: The varied and uneven terrain of mountainous regions, with small and scattered plots of arable land, often in strips or terraces, limits the use of large agricultural machinery, increasing the difficulty and cost of farming. The main way to enhance production capacity is, therefore, to increase the yield per unit area. 2) Fragile Ecological Environment: Although mountainous regions have high biodiversity and a wide variety of flora and fauna, providing good conditions for developing specialized and ecological grain farming, the ecological environment in these areas is fragile, sensitive, easily disrupted, and damaged. The dilemma of balancing protection and development is, therefore, prominent.

3) Inadequate Infrastructure: The high cost and complexity of the construction of transportation, water conservancy, and communication infrastructure in mountainous regions means infrastructure is limited, with high transportation costs and low logistics efficiency, adversely affecting the market circulation and economic benefits of grain.

3.2 Unique Development Positioning in Mountainous Regions

Natural Environment Challenges: The complex terrain, uneven water resource distribution, and significant climate variability in mountainous regions pose threats to the safety of agricultural production owing to natural disasters.

Fragmented Operations Challenges: The arable land in mountainous areas is mainly on slopes and terraces, with low mechanization levels, making farming difficult.

Infrastructure and Transportation Challenges: Poor transportation and infrastructure limits grain circulation and market expansion. Mountainous regions also possess many advantages over other regions.

Ecological Environment Advantages: Low pollution, clean air, and good water quality in mountainous areas provide unique conditions for developing green and organic agriculture.

3.3 Unique Development Positioning in Mountainous Regions

Based on the inherent characteristics of mountainous areas, the advantages and disadvantages of grain development, and market demand, the grain industry in mountainous regions must explore differentiated development paths suitable for the characteristics of these regions.

The first opportunity to do this arises from the comparative advantage of smallholders, family farms, specialized large households, agricultural cooperatives, and leading enterprises in the grain industry, which strengthen specialized production, resource integration, and division of labor coordination. This should be achieved by improving the linkage mechanisms of interest and optimizing collaborative relationships for efficient grain production.

Second, there is a need to adhere to both government and market forces to promote the sustainable development and activate internal driving forces to ensure food security in mountainous areas. Strategies could include both the improvement of policy coordination and innovation of market mechanisms, encouraging mountainous regions to improve varieties, enhance quality, and build brands to increase the added value and market competitiveness of grain products. Such an approach can enhance the endogenous development momentum of the grain industry in these areas.

4. Multiple Challenges Facing the Grain Industry in China's Mountainous Regions

4.1 Resource Constraints

The arable land in mountainous regions is mainly sloped, with a limited area and scattered distribution. Complex terrain significantly restricts the level of agricultural mechanization and the possibility of large-scale farming. Achieving contiguous farming development is difficult, making it challenging to increase yields through simple expansion of individual farm sizes. In addition, owing to the fragmentation of resources, integration involves high time and transactional costs, further deterring social capital investment and limiting industrial upgrades and development. The ecological systems in mountainous regions are relatively fragile, and some areas are significantly affected by mudslides, earthquakes, landslides, and other natural disasters. The lag in improving agricultural production methods, the irrational use of inputs, such as pesticides and fertilizers, and overcultivation and overgrazing have led to severe soil erosion and irreversible soil degradation.

4.2 Market Constraints

Geographical, Transportation, and Communication Constraints: With urban clusters becoming leading regional economic development hubs, most mountainous areas remain remote with less-developed transportation, communication, and network facilities. This results in high and time-consuming transportation costs, making it difficult to sell grain products and introduce advanced varieties and technologies.

Lagging Standardization of Grain Production: Owing to general small-scale farming in mountainous areas, it is challenging to achieve standardized and refined grain-production processes, leading to high production costs and uneven grain product quality. Compared to other regions with large-scale standardized grain production, mountainous grains cannot achieve competitive advantages nor meet the demand for quality-stable products in the subsequent processing, storage, and marketing stages.

An Incomplete Grain Industry: Grain processing and storage facilities are often inadequate in China, leading to loss and spoilage of agricultural products. The sales network is also underdeveloped and lacks effective market promotion and sales channels. The construction of external sales platforms and brand building is relatively slow, making it difficult for grain products to enter broader markets.

5. Paths for Ensuring Food Security in China's Mountainous Regions

5.1 Promote the Development of Appropriately Scaled Operations

First, based on scientific land consolidation planning, engineering measures should be taken to promote the concentration and consolidation of land as much as possible by adopting differentiated land improvement models such as gentle slopes, terraces, and strip fields to eliminate fragmented plots. After the rational adjustment of plots, soil improvement should be conducted based on plot conditions to facilitate irrigation, drainage, and small-scale mechanized farming. Second, multiple structural improvements are needed to enhance industrial benefits. Given the inherently fragmented arable land in mountainous areas that cannot be fundamentally changed, and the difficulty in improving production efficiency and benefits through scale effects, it is essential to focus on cost reduction and quality improvement in grain production in these areas, targeting technical improvements and optimizing basic industrial layouts, emphasizing product quality control and pursuing a small-scale, unique developmental pathway.

Comprehensive Social Service Strategy: Mountainous agricultural planting is predominantly smallholder based, with limited information access, small per-household arable land area, and uneven distribution. Therefore, comprehensive social services that focus on small, specialized, and high-quality needs are necessary. Accelerating the cultivation of professional social service organizations and enhancing the capacity to provide full-chain services for smallholder grain production would be highly advantageous. transportation, processing, and sales.

5.2 Innovate Composite Planting Models

1) Explore Integrated Crop–Livestock Models: The grain industry in mountainous areas should pursue high-quality development through ecological crop–livestock combinations, provide channels for manure absorption from livestock farming while reducing the destruction of soil and water quality by chemical inputs, and achieve a positive cycle of ecological environmental protection and sustainability.

2) Explore Intercropping Composite Development Models: A "grain crops+economic crops+feed crops" three-component production model should be explored to effectively improve the production quality and efficiency of crops while reducing the use of pesticides and fertilizers. This can effectively coordinate the development of ecological agriculture and food security while achieving higher economic returns per unit area.

Explore "Agriculture+Rural Tourism" Composite Agricultural Models: The unique ecological, historical, and cultural resources of mountainous areas should be utilized, combining them with the unique landscape of grain industry development to develop new industries and businesses such as eco-tourism and homestays, promoting the diversification of rural economies and extending the industrial chain, thereby driving overall economic development in rural areas. More importantly, the production of multiple agricultural products disperses the market price fluctuation risks of single crops and increases the economic benefits of agricultural production, thus becoming an important way to increase the income of farmers in mountainous areas.

5.3 Adhere to Ecological Development Models

Strengthening Ecosystem Protection and Restoration: This includes implementing pollution prevention and control actions for the grain industry; conducting heavy metal-contaminated soil restoration; incentivizing the use of organic fertilizers, biological pesticide technology, and agricultural film recycling; promoting utilization of agricultural inputs; and establishing a regulatory mechanism for grain ecological compensation.

Promoting the Establishment of High-Quality Ecological Grain Brands: This includes improving the comprehensive capacity of the grain industry; formulating standards for high-quality grain production; promoting the "branding" of grain in mountainous areas; and, through developing customized agriculture and "Internet + Agriculture", improving the transaction mechanism for "high-quality, high-price" green agricultural products. Enhancing the discourse power of mountainous ecological products in brand evaluation, accelerating the process of branding grain from mountainous areas, both nationally and globally, are similarly important goals.

Promoting Green Efficiency and Agricultural-Tourism Integration: Following the principles of "stable area, increased yield, green efficiency, demand-led, and optimized structure," green efficiency actions for grain should be comprehensively promoted. This requires exploring and promoting distinctive ecological agricultural products from mountainous areas through organic and green food certification to enhance market recognition; increasing consumer trust; and creating locally branded agricultural products. Based on local ecological resources and industrial advantages, there is a need to carefully plan, scientifically layout, and promote the integration of "grain + tourism" industries, leveraging local ecological advantages to create a new common prosperity industry in rural mountainous areas.

5.4 Further Improve Support Policies

1) Policy Optimization: To address the limited profitability space of grain planting, there is a need to increase support for integrated crop-livestock systems, green agriculture, and ecological cycles, encouraging innovation in "paddy field + grain industry" models to increase grain income. Based on the demand for industrial cluster development, industrial planning and layout optimization should also be promoted at all levels of government to facilitate group and appropriately concentrated development. This can also support the development of leading agricultural enterprises in mountainous areas through policies that leverage their role in technological innovation, market expansion, and industrial chain integration.

2) Policy Integration: It is crucial to strengthen cooperation among agricultural and natural resources, water conservancy, and fiscal departments to enhance comprehensive support for infrastructure such as roads, canals, and ditches in grain production areas, which will significantly improve the overall production capacity of grain.

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