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A HOLISTIC ASSESSMENT OF CHINA'S FOOD SECURITY AND THE FACTORS HINDERING ITS PROGRESS

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ABSTRACT
Food security in the People's Republic of China has been a paramount concern, shaped by its historical experiences and contemporary challenges. This article presents a comprehensive examination of China's food security status, exploring both the facilitating and hindering factors in its pursuit of a stable and sustainable food supply. The historical context underscores China's commitment to addressing food security, with agricultural modernization, policy initiatives, and diversification of food sources playing crucial roles in progress. However, environmental challenges, changing dietary patterns, and income disparities present formidable obstacles. Balancing the achievements and ongoing challenges highlights the intricate nature of China's journey toward food security.
KEYWORDS: *Food Security, China, Agricultural Modernization, Policy Initiatives, Diversification, Historical Context, Sustainability, Utilization, Regulation*

INTRODUCTION
China's food security is gaining global focus due to increasing instability and unpredictability. This research devised a fresh approach to evaluate China's food security, focusing on its accessibility, allocation, usage, susceptibility, sustainability, and governance. The analysis utilized a combination of the entropy weight method (EWM) and the matter-element extension model (MEEM) to study the state of China's food security from 2001 to 2020. Moreover, an obstacle degree model (ODM) was applied to identify the primary elements obstructing food security. The study revealed that while China's overall food security saw substantial enhancement, it experienced a minor decline in 2003. The primary challenges initially revolved around grain distribution, later expanding to issues related to vulnerability and sustainability. The most significant factors constraining China's food security were identified as the quantity of fertilizer used per unit of sown area (AFA) and the self-sufficiency rate of grain (GSR). The forthcoming 40 years could be crucial in guaranteeing China's food security, which involves factors like demographics, climate change, and resource scarcity. It appears that China is enacting its national strategies via sustainable farmland usage and innovative agricultural technology to promote the high-quality growth of its grain industries and bolster its food security.

LITERATURE REVIEW
Food security is a fundamental concern for the People's Republic of China, given its vast population and evolving socio-economic landscape. As China experiences rapid urbanization, environmental challenges, and shifts in dietary patterns, ensuring a stable and sustainable food supply has become an intricate policy objective. This literature review delves into a comprehensive examination of China's food security status and explores the multifaceted factors that both facilitate and hinder its progress in this critical domain.

China has a complex history of food security challenges. Memories of severe famines, such as the Great Famine of 1959-1961, have driven the nation's commitment to addressing food security. The post-reform era, marked by economic liberalization, brought significant changes to agricultural production and rural livelihoods. State-led initiatives, including the Household Responsibility System, shifted control over land and crops to individual households, stimulating agricultural productivity (Rozelle et al., 1997).

China's pursuit of food security hinges on agricultural modernization. Substantial investments in research and technology, such as high-yield crop varieties and precision agriculture, have led to increased yields and productivity. Mechanization and irrigation improvements further enhance agricultural efficiency (Huang et al., 2020).

The Chinese government has implemented a range of policies to bolster food security, such as subsidies for farmers, the Minimum Purchase Price (MPP) system, and a strategic grain reserve. These policies aim to stabilize food production and ensure adequate grain stocks (Fan et al., 2013). International trade agreements and investments in foreign agriculture have diversified China's food sources. Importing agricultural products, including soybeans and grains, has become a vital strategy to meet domestic demand (Zhang et al., 2018).

China grapples with the environmental impact of intensive agriculture. Soil degradation, water scarcity, and pollution pose significant threats to the long-term sustainability of food production. Addressing these challenges while ensuring food security remains a complex task (Zhang et al., 2021).

Changing dietary patterns have led to increased demand for meat and dairy, straining resources. This shift poses both environmental and health challenges. Balancing dietary preferences with sustainability is a pressing concern (Wang et al., 2019).

Rural-urban income disparities persist, affecting access to food. While urban areas enjoy greater food choices and access to nutrition, rural regions face challenges related to affordability and food quality (Glauben et al., 2019).

ANALYSIS AND DISCUSSION

Food security is a fundamental element for national stability and human welfare, hence it is a critical precondition for national security[1]. In recent times, food security has become a pressing issue in both developing and advanced parts of the globe[2], with the situation being particularly dire in Asia and Africa, where the count of individuals facing hunger peaked at 418 million and 282 million respectively in 2020[3]. China, with one-fifth of the global population, is dealing with varied levels of food production stress. Maintaining food security and catering to the needs of its vast populace requires increased grain production, despite only having 9% of the world's arable land and 6% of global water resources at its disposal[4]. This indicates a growing environmental and resource challenge. Factors like climate change, urbanization, and a shift in dietary habits from grains to more meat-centric diets further exacerbate this situation[5]. As such, a multifaceted examination of China's food security situation will facilitate a more thorough and unbiased evaluation; both quantitative and qualitative assessments of the impediments impacting China's food security status are crucial for setting the main objectives of China's food security strategy and agricultural policy.

Food security has been a growing concern for governments and scholars for several decades. The concept was first defined at the 1974 World Food Conference in Rome, Italy, as 'ensuring that all people at all times have access to enough food for survival and health'[6]. The 1996 World Food Summit Plan of Action further refined the concept, with the most widely accepted definition stating 'when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life'. Since its introduction, food security has been widely studied internationally[7]. Some research suggests that food security is about availability, utilization, and sustainability, while others perceive it as the eradication of poverty, malnutrition, and hunger. Most current studies, however, neglect the potential friction between food sustainability and other dimensions of food security, and policy applications have received limited attention. Hence, in this research, food security is defined as a 'condition where a region or nation can satisfy sustainable and ecological standards, supply people with ample nutritious and healthy food that aligns with certain cultural habits and preferences under the government's macro-control and market regulation mechanism'.

Understanding that the creation of an evaluation index system is pivotal to the evaluation procedure, this research focuses on developing an unbiased and rational food security evaluation index system. Drawing from past studies, this paper considers the comprehensive strategy for grain availability and distribution. It emphasizes the crucial role of the vulnerability and sustainability of grain production, and the effective and efficient use of resources in ensuring food security. It also integrates governmental regulation with the enhancement of food security. As a result of the above analysis, an evaluation index system made up of 22 evaluation factors for China's food security is proposed (Table 1). This system is categorized into six main components: availability, distribution, utilization, vulnerability, sustainability, and regulation. The chosen indicators align with established principles of completeness, comparability, dynamism, and practicality.

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Table 1. Evaluation index system of China's food security.

Index/Unit		Index Definition/Explanation
Availability (A)	Total grain production (TGP)/10^4 ton	Total output of grain produced within a calendar year
	Grain yield per unit area (GY)/(kg/hm^2)	Productive capacity of cultivated land within a region
	Grain self-sufficiency rate (GSR)/%	Grain production/(grain production + imports − exports)
	Planting structure of grain crops (PSG)/%	Proportion of the total sown area of grain crops to farm crops
Distribution (D)	Per capita grain availability (pGA)/(kg/person)	Total grain production/total population
	Per capital daily total intake (pDTI)/(kcal/day/person)	(Total grain production + net grain import) × grain comprehensive calories/(total population × 365)
	Per capita disposable income of residents (pDIR)/RMB	Purchasing power of residents
	Grain price volatility index (GPVI)/preceding year = 100	Grain retail price fluctuant trend and degree
	Density of highways and railways (DHR)/10^4 km	Effectiveness of transportation in grain distribution and access
Utilization (U)	Prevalence of undernourishment (PU)/%	Proportion of the population failing to meet dietary needs for a healthy life to the total population
	Loss rate (LR)/%	Utilization efficiency of five main crops in each stage (rice, wheat, corn, beans, and tubers)
	Poverty incidence (PI)/%	Impoverished population/total population
Vulnerability (V)	Grain reserve level (GRL)/%	Stock variation of state-owned grain enterprise
	Per capita sown area of grain crops (pSA)/(hm^2/person)	Sown area of grain crops/total population
	Grain production fluctuation coefficient (GFC)/%	Fluctuation range of grain production
	Occurrence of natural disasters (OND)/case	Number of natural disasters in a year
Sustainability (S)	Amount of fertilizer application per unit sown area (AFA)/(kg/hm^2)	Consumption of chemical fertilizer/sown area of grain crops
	Effective irrigation area (EIA)/10^3 hm^2	Area of cultivated land under normal irrigation for agricultural production
	Area affected of grain crops (AAG)/10^3 hm^2	Extent of grain production affected by disasters
	Level of agricultural machinery (LAM)/10^4 kW	Effect of science and technology support on agricultural sustainable development
Regulation (R)	Per capita level of government expenditure for supporting rural production (pSRP)/(RMB/person)	Government expenditure for supporting agricultural development
	Proportion of government expenditure for supporting agriculture to agricultural output value (PAGE)/%	Government expenditure for supporting agriculture/gross output value of agriculture

In the context of China's statistical data, grain output includes cereals, beans, and tubers categorized by crop type. The data for total grain production (TGP), output of major farm products, grain imports and exports, planting structure of grain crops (PSG), per capita disposable income of residents (pDIR), affected area of grain crops (AAG), per capita level of government expenditure for supporting local production (pSRP), and proportion of government expenditure for supporting agriculture to agricultural output value (PAGE) were gathered from the Statistical Yearbook released by China's National Bureau of Statistics and the China Rural Statistical Yearbook. These span various years from 1991 to 2020. Historical annual data, which include the length of highways and railways, the quantity of agricultural fertilizer application, the sown area of grain crops, and the effective irrigation area, were sourced from the Achievements of New China's Economic and Social Development in 70 Brilliant Years (1949–2019).

Poverty incidence data was taken from the Poverty Monitoring Report of Rural China. The grain price volatility index was extracted from the annual data in the China Urban Life and Price Yearbook. The data on the prevalence of undernourishment (3-year average) and cereal stock variation were obtained from FAOSTAT Data of the FAO (United Nations). Natural disaster statistics were downloaded from the Emergency Events Database (EM-DAT) of the Center for Research on the Epidemiology of Disasters (CRED) (http://www.emdat.be/ accessed on 9 March 2021). Any gaps in the data were filled using the interpolation method.

The obstacle degree model (ODM) is a useful tool for identifying and analyzing influence factors, pinpointing the key variables that significantly impact evaluation outcomes, clarifying the impact level of key constraints, and assisting in the sustainable development of grain output and better assurance of China's food security. Hence, this paper introduces three elements - index contribution (wj), indicator deviation (Tij), and obstacle degree (Oj) - to ascertain the obstacle degree of the factors affecting food security. The calculation method for these is detailed as follows:

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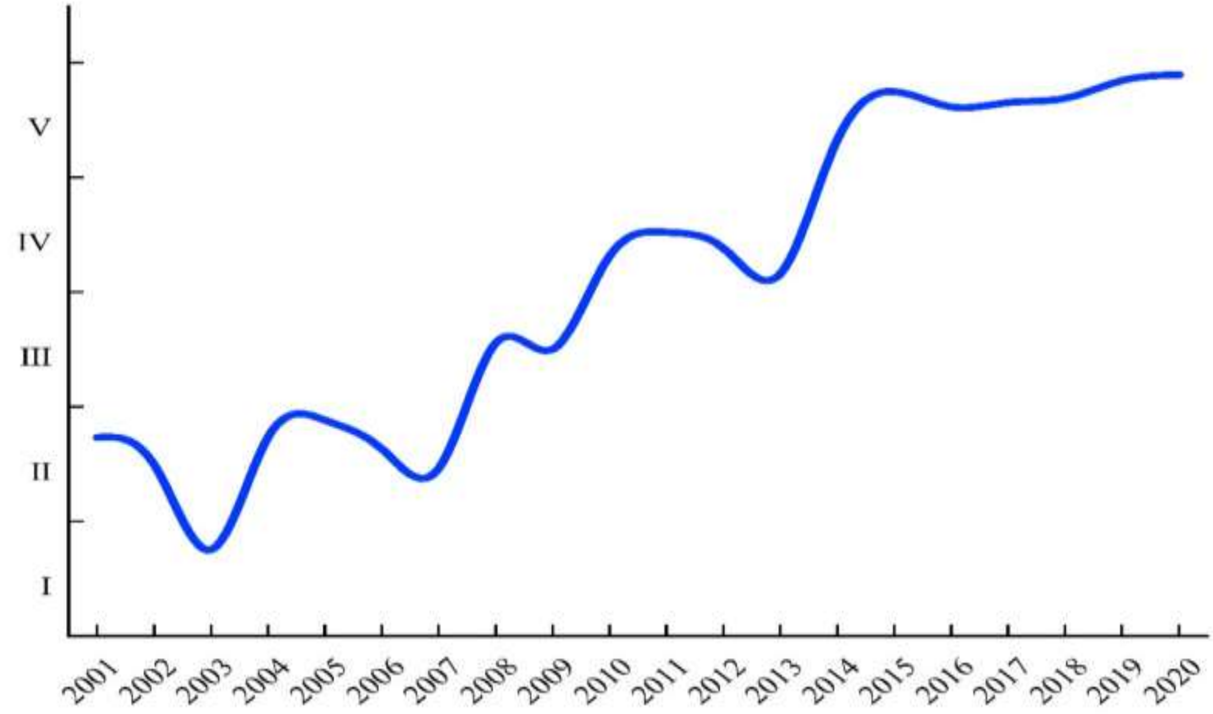
$$Tij=1-zij$$

$$Oj=wj\times Tij\sum ni=1(wj\times Tij)\times 100\%$$

where *Oj* represents the obstacle degree of the *j* th indicator on the safety state, which means the influence degree of each indicator or unit on the overall food security status. *zij* is the normalized value of the single index, and *Tij* refers to the deviation degree of the indicator, which represents the difference between the actual indicator value and the optimal target value.

A trend map depicting the status of food security in China from 2001 to 2020 can be created based on the comprehensive correlation degree and evaluation grade. The figure reveals that, with the exception of a period of relative insecurity in 2003, China's overall food security demonstrated a marked upward trend with intermittent fluctuations throughout this timeframe. In 2003, the planted area for grain crops in China fell below 100 million hectares, representing 65.2% of the total crop sown area - a record low[8]. Another possible reason for this could be that China's food security is influenced by international grain prices and the affordability of food for its citizens. The food production saw a considerable decline in 2003, which resulted in the first increase in China's food market prices in six years, and international food prices also saw a rise.



Pic.1. China's food market prices

Post 2003, China experienced 17 consecutive years of abundant harvests. These years saw sufficient grain supplies and reserves and a stable grain market, which are indicators of improving food security. However, the variations in the comprehensive correlation degree curve of food security indicate that an increase in total grain output alone cannot ensure China's food security, as it is the result of the combined effect of multiple factors. Therefore, it relies on maintaining the sustainability and stability of agricultural production, predicated on the steady enhancement of food production. It also depends on giving precedence to the conservation of resources and the environment, bolstering agricultural infrastructure development, augmenting agricultural production capacity and risk response ability, and ensuring long-term stability.

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Table 1.
Top five obstacle indicators of China's food security during 2011–2020.

Year	Option	Indicator Order				
		1	2	3	4	5
2011	Indicator	AFA	pDIR	LR	pSRP	GRL
	Value	20.0	11.1	8.6	8.4	7.1
2012	Indicator	AFA	pDIR	LR	pSRP	GSR
	Value	23.1	11.1	7.6	7.0	6.5
2013	Indicator	AFA	pDIR	LR	GSR	OND
	Value	24.8	10.6	7.6	7.3	6.5
2014	Indicator	AFA	pDIR	GSR	OND	pSA
	Value	27.6	10.2	9.0	6.8	6.3
2015	Indicator	AFA	GSR	pDIR	pSA	OND
	Value	32.3	12.4	10.3	7.1	6.7
2016	Indicator	AFA	GSR	pDIR	GRL	pSA
	Value	30.1	11.0	8.0	7.4	6.9
2017	Indicator	AFA	GSR	GRL	pSA	pDIR
	Value	31.1	12.8	9.2	8.2	6.3
2018	Indicator	AFA	GRL	GSR	pSA	pSRP
	Value	28.5	12.5	11.2	8.6	5.7
2019	Indicator	AFA	GRL	GSR	pSA	LR
	Value	29.5	14.2	12.1	10.3	6.8
2020	Indicator	AFA	GSR	GRL	pSA	PAGE
	Value	34.5	18.5	18.2	12.6	6.3

Table 1. illustrates the primary obstacles among the 22 indicators of China's food security during the period of 2011–2020. The table identifies that the top five obstacle factors are primarily embodied in the sustainability and vulnerability aspects of food security. Specifically, from 2011 to 2020, the largest constraining factor affecting food security was the Amount of Fertilizer Application per unit sown area (AFA). This implies that there are substantial disparities in land quality grades across the nation. In the absence of sufficient fertile farmland, soil fertility is enhanced by increasing the application of chemical fertilizers, which severely hampers sustainable agricultural production.

Meanwhile, from 2011 to 2014, the condition of grain distribution also influenced China's food security, and Per Capita Disposable Income of Residents (pDIR) emerged as the second largest risk factor. However, post-2014, the Grain Self-Sufficiency Rate (GSR) has gradually become the second largest risk factor limiting the development of China's food security. As has been discussed, this is due to the swift increase in imports of corn and soybeans; China's actual grain self-sufficiency rate has been on an overall downward trajectory, the structural contradiction of grain varieties in China has escalated, and the development of the agricultural structure has become unbalanced. Furthermore, the Grain Reserve Level (GRL) and the Proportion of Sown Area (pSA) have been decreasing slowly, indicating that China's grain production lacks sufficient stability and is an obstacle to food security development. In recent years, due to constraints posed by natural conditions, climate change, market conditions, and other factors, the stability of food production has also had a critical influence on China's food security.

This study employs a scientific methodology to comprehensively and effectively evaluate China's food security, a crucial element in shaping the primary objectives of China's food security strategy and agricultural policy. The results indicate a general upward trend in China's food security status from 2001 to 2020, with a slight dip in 2003. This supports the consistent improvement of

China's overall food security status. These findings are corroborated by Wu et al.[9] and Yao et al.[10], who observed a reduction in grain sowing area and an increase in cash crop planting area amidst changes in China's agricultural structure in 2003, leading to a substantial decrease in China's total grain output.

Grain availability is the primary factor influencing food security. The rapid advancement of agricultural science and technology indeed contributes to a steady enhancement of China's comprehensive grain production capacity. However, as the world's largest grain importer, China imports a large quantity of grain annually[11]. Despite achieving almost full self-sufficiency in cereal production, akin to several populous developing countries and slightly lower than developed countries, soybean self-sufficiency has notably declined[12]. In 2020, China sourced 73.0% of its imported rice from Vietnam, Pakistan, Thailand, and Cambodia. Alongside rice, wheat, and corn are primarily imported from resource-rich countries or regions such as the United States, Brazil, Argentina, and the European Union[13]. China's dependence on foreign countries for soybean has reached an extremely high level, with imports skyrocketing from 13.9 to 100.3 million tons between 2001 and 2020. Major soybean importers include Brazil, the United States, and Argentina, with Brazil accounting for 64% of the total[14]. Therefore, there is a need for further promotion of agricultural layouts and grain planting structures, stabilization of grain planting areas, and cultivation of potatoes, beans, miscellaneous grains, and other crops based on local conditions.

\On the other hand, agricultural costs continue to escalate, and the capacity of resources and the environment is nearing its limits[15]. We infer that due to China's low agricultural production capacity and extensive agricultural management, the ecological environment remains very fragile, significantly hindering improvement in grain production capacity. In 2019, agricultural chemical fertilizer consumption exceeded 55 million tons, and the Amount of Fertilizer Application per unit sown area (AFA) for farm crops remained at 325 kg/ha, considerably higher than the global average (120 kg/ha). Other data indicate that in 2019, the amount of pesticide application was 8.7 kg/ha, 3.3 times the global average[16]. These statistics highlight that China's agriculture remains extensive, with low technical knowledge, economic efficiency, and economies of scale. Agricultural producers often employ excessive and predatory production modes, applying large quantities of chemicals such as pesticides, chemical fertilizers, and herbicides, and indiscriminately discharging livestock and poultry waste and domestic pollutants, leading to the degradation and desertification of cultivated land resources. Agricultural infrastructure is relatively weak, and the capacity for disaster prevention and relief must be improved. Moreover, unpredictable weather events have caused sharp declines in grain production and residents' incomes in vulnerable areas, significantly increasing the risk of food insecurity. China faces substantial pressure to maintain steady grain production while ensuring green development and sustainable resource utilization. Consequently, agricultural producers should control the application of chemical fertilizers and pesticides based on soil fertility, continue to reinforce the treatment of agricultural nonpoint source pollution, and strive for high-quality agricultural development.

CONCLUSION

China's pursuit of food security is a dynamic process marked by significant achievements and enduring challenges. The nation's commitment to agricultural modernization, policy initiatives, and diversification of food sources has enhanced food security. However, environmental challenges, dietary shifts, and income disparities remain substantial hurdles. Navigating these challenges while ensuring sustainable and secure access to food is a multifaceted endeavor, highlighting the complexity of China's journey to food security.

In view of severe food security challenges, China has a long way to go to facilitate the high-quality development of its grain industries and strengthen the food security guarantee. China will implement its national strategies for food security through sustainable farmland use and agricultural technology innovation to increase farmland productivity. At present, China has carried

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out soil testing and formula fertilization; popularized the practice of returning straw to the field, green manure planting, the application of organic fertilizer, soil improvement, and other supporting technologies; and steadily improved the quality of cultivated land. China will continue to innovate in the seed industry, making breakthroughs in core technologies such as germplasm improvement and the creation, efficient cultivation, processing, and circulation of new crop varieties. China will enhance integrated technological innovation, breaking logjams in improving per unit area yield, crop quality, economic benefits, and the environment. At the same time, China intends to strengthen macroeconomic regulation and its support of agriculture, promote mechanization in agriculture, transform and upgrade the agricultural machinery industry, increase the grain supply, and improve grain quality through the application of agronomy and agro techniques.

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