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Evaluation of crop structure optimization policy quantitatively and future directions in China: a PMC-Index model approach

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Developing policies to optimize the planting structure is essential to ensure an adequate supply of agricultural products and guarantee food security. However, the rationality and comprehensiveness of China's cropping structure optimization policies require scientific evaluation. Therefore, this research established an evaluation index system for China's planting structure optimization policies using text mining and the PMC-Index model to evaluate eight agricultural cropping structure optimization policies in China since 2003. The results showed that: (1) The PMC-Index showed a general upward trend across the eight policies, with scores ranging from 4.88 to 6.61. (2) Seven of the eight policies were deemed acceptable, while one was classified as low. (3) The Chinese government has long focused on optimizing the structure of agricultural cultivation, and relevant policies have made significant progress in terms of logical connotation and long-term feasibility. However, there is still room for improvement in enhancing regulatory effectiveness and strengthening interdepartmental collaboration. It is recommended that the government develop more flexible and diverse incentive mechanisms, strengthen interdepartmental coordination, expand policy coverage, enhance the comprehensiveness of policy functions, and elevate support for agricultural technology.

KEYWORDS
policy evaluation, food safety, crop structure, policy proposals, China

1 Introduction

Crop planting structure optimization involves adjusting the proportions and spatial distribution of various crops to maximize the efficient use of agricultural resources, improve production efficiency, ensure food security, and promote sustainable development. The effectiveness of crop planting structure optimization policies is crucial for reducing resource and environmental pressures, addressing supply and demand imbalances in agricultural products, and enhancing overall food production capacity (Niu et al., 2022). However, the ongoing processes of urbanization and industrialization have intensified the conflict between humans and land, reducing cultivated land and compressing the space available for crop cultivation. China's cultivated land area decreased from 130.04 million hectares in 2000 to 127.43 million hectares by 2020. At the same time, the uneven distribution of water and soil resources has resulted in regional disparities in agricultural productivity, further exacerbating structural and geographical imbalances in agricultural production. Northern regions primarily focus on grain crops like corn and wheat, while southern regions are dominated by rice, vegetables, and fruits (Leipnik et al., 2014). To increase yields, some regions have adopted highly intensive farming practices, with excessive use of chemical fertilizers and pesticides. This has let to soil degradation, a decline in cultivated land quality, and threats to the safety of farmland ecosystems (Lu et al., 2020). Therefore, the Chinese government has consistently introduced policies to adjust cropping structures, with the aim of stabilizing the quantity of cultivated land, improving its quality, and protect its ecosystems, thereby ensuring a stable and secure national food supply. These policies also aim to effectively address resource and environmental pressures, enhance agricultural economic benefits, increase farmers' incomes, and promote sustainable agricultural development. However, the comprehensiveness, effectiveness, and sustainability of these crop structure optimization policies remain uncertain, highlighting the urgent need for systematic evaluation through scientific methods.

Research has shown a reciprocal relationship between crops and cultivated land (Song & Zhang, 2021). Crop production depends on the soil, nutrients, and space provided by cultivated land, with the quality and quantity of the land directly affecting crop growth and yield. At the same time, the structure and layout of crop planting play a crucial role in the efficient use of cultivated land and its ecological environment. Therefore, linking cropping structure with land utilization is essential. While research evaluating farmland protection policies is relatively abundant, studies that directly assess policies aimed at optimizing cropping structures are still quite rare. Most research on farmland protection policies employs methods such as literature review (Liu & Zhang, 2021), inductive reasoning (Liu & Wang, 2021), and theoretical analysis (Liang et al., 2022) to clarify the internal logic behind the evolution of these policies (Kuang et al., 2020; Wang et al., 2020) and assess their effectiveness (Lu et al., 2021), ultimately proposing transformation pathways for land protection (Wu & Shen, 2021). Studies that focus on evaluating optimization policies for crop planting structure tend to examine the effects and driving mechanisms of specific measures, such as planting structure adjustment compensation (Liu et al., 2015), grain production subsidies (Zhou et al., 2021), and price support (Li & Lin, 2022). However, these studies often lack a thorough evaluation of policy consistency and rationality, and they fail to consider the deeper implications of cropping structure adjustments. As a result, the relationship between cropping structure, cultivated land utilization, and food security has been largely overlooked. In terms of methodology, approaches such as AHP-fuzzy comprehensive evaluation (Shi et al., 2020), the DPSIR model (Shi, 2022), the PMC-Index model (Meng & Xu, 2023), and social network analysis (Drew et al., 2011) are commonly used. Among the various approaches, the PMC-Index model stands out due to its multidimensional evaluation system. Firstly, the PMC model can assess the comprehensiveness of policy content in relation to stabilizing cultivated land quantity, improving land quality, and protecting ecosystems. Secondly, the PMC model reduces bias in subjective assessments by quantifying the alignment between policy goals and actual outcomes through standardized input–output tables. This is crucial for crop structure policies involving complex stakeholders. Additionally, the PMC model enables dynamic tracking of policy implementation progress, assisting the government identify issues and adjust policy direction in a timely manner, particularly when addressing regional disparities in agricultural productivity and environmental pressures. This approach ensures the efficient allocation of policy resources and funding. Therefore, applying the PMC model to evaluate crop structure optimization policies can more effectively identify policy strengths and areas needing improvement, providing clear direction for subsequent policy optimization. Given this context, the present study takes into account the relationship between crops and cultivated land and applies text mining alongside the PMC-Index model to develop an evaluation system for optimizing crop planting structure policies in China. The study provides a quantitative assessment of the comprehensiveness, systematic nature, and sustainability of eight representative policies aimed at optimizing cropping structures, while also discussing the potential impact of policy implementation on the planting structure. The goal is to offer scientifically grounded recommendations for improving the policy framework for optimizing crop planting structures. The structure of this paper is as follows: The first section reviews the evolution of China's crop structure optimization policies; the second section outlines the research methods and data sources; the third section presents the research findings; the fourth section explores potential pathways for policy improvement; and finally, the conclusion summarizes the key findings.

2 Policy evolution process

Over the past forty years, China's crop planting structure has experienced significant changes, reflecting the country's ongoing adjustments to priorities in food security, economic development, and environmental protection. To effectively select policy analysis samples, this paper provides a comprehensive review of the evolution of China's crop planting structure optimization and its related policies, with a particular focus on the key phases of this development process.

2.1 Increasing grain production (1978–1993)

China's agricultural policy reform began in 1978 with the introduction of the Household Responsibility System, which marked a significant transition from collective farming to household-based management. This shift led to a substantial increase in grain production (Gong, 2018). The primary goal during this period was to maximize grain output to ensure food security, particularly in response to the demands of a rapidly growing population. Key measures included promoting the high-yield crops like hybrid rice, with supported by subsidies and incentives to stimulate grain production. By the early 1990s, China had largely achieved self-sufficiency, setting the stage for the subsequent phase of crop planting structure adjustment.

2.2 Economic crop development (1994–2003)

With food security largely addressed, the focus of agricultural policy in the mid-1990s shifted toward optimizing crop production structure. The government encouraged reducing grain crop planting areas while expanding the cultivation of economic crops like fruits, vegetables, cotton, and tea, which offered higher market value and aligned with changing domestic and international market demands. During this phase, policies emphasized agricultural diversification, particularly promoting the expansion of economic crops to increase farmers' income. At the same time, farmland protection policies gained increased attention to ensure the sustainability of agricultural production.

2.3 Modern agriculture promotion (2004–2012)

In the early 21st century, China introduced the New Rural Construction strategy, which sought to integrate agricultural structure adjustments with modern agricultural development to improve rural living standards and agricultural productivity. During this phase, the optimization of crop planting structures intensified, with a focus on balancing the cultivation of grain and economic crops. The government also placed increased emphasis on farmland protection, establishing a nationwide minimum for cultivated land. This policy ensured the stability of cultivated land, providing a foundation for the continued optimization of crop planting structures.

2.4 Supply-side structural reform (2013–2019)

The introduction of supply-side structural reforms in the agricultural sector in 2013 marked a new phase in China's agricultural policies. The focus of crop planting structure optimization shifted toward reducing inefficient and surplus production, increasing the supply of high-value-added agricultural products, and promoting comprehensive rural development through the Rural Revitalization Strategy. During this phase, the government strictly regulated the non-agricultural use of farmland to ensure stable agricultural land use, supporting both the supply-side structural reforms and the continued optimization of crop planting structures.

2.5 Green agriculture development (2020–Present)

In recent years, as global climate change and environmental concerns have intensified, China's agricultural policies have shifted toward green agriculture and sustainable development (Wang et al., 2023). The objective of crop planting structure optimization during this phase has been to promote environmentally friendly and organic farming practices, reduce negative environmental impacts, and simultaneously enhance crop yield and quality. To support green agriculture, the government implemented stricter farmland protection policies, including prohibiting non-agricultural use of cultivated land and restricting the conversion of farmland from grain production to other purposes.

Overall, China's crop planting structure optimization policies have evolved from ensuring food security to promoting agricultural diversification and, more recently, toward sustainable development and green agriculture. The year 2003 marked a pivotal shift from a focus on food self-sufficiency to a more balanced approach to crop cultivation. Evaluating China's crop planting structure optimization policies after 2003 not only helps address challenges related to climate change and environmental protection but also explores the balanced development of food security and cash crops. Additionally, these policies offer valuable insights into agricultural transformation and rural revitalization for other developing countries, holding significant international relevance.

3 Materials and methods

3.1 Selection of the research sample

China's crop planting structure faces challenges such as regional imbalances and significant differences in crop types between the North and South. To objectively assess the consistency, comprehensiveness, and rationality of relevant policies, this study identified representative policies based on four main criteria: (1) Comprehensive national policies. Unlike provincial or regional policies, national policies provide comprehensive planning at the national level, balancing resource allocation and crop structure across different regions. These policies also mobilize resources such as funding, technology, and personnel on a nationwide scale, ensuring greater consistency and authority in both policy formulation and implementation. (2) Policies issued at key milestones with guiding principles. These include policies that introduced significant viewpoints or forward-looking strategies, particularly those issued at crucial moments. (3) Policies highly correlated with high-frequency terms. This criterion is based on text mining results, where policies closely associated with frequently mentioned terms were selected. (4) Currently effective policies. As socio-economic conditions evolve, governments may adjust policy content to adapt to new realities driven by market demands, technological advancements, or environmental changes. Some policies may be categorized as obsolete. This study focuses on currently effective policies to ensure the adaptability and sustainability during evaluation.

Since 2003, China's grain production has steadily increased, closely linked to the government's continued efforts to promote crop structure optimization policies. A systematic review of the evolution of these policies reveals that 2003 marked a critical turning point in China's crop structure policy. During this period, the focus shifted from solely prioritizing grain production to promoting the coordinated development of both grain and cash crops. The aim was to optimize agricultural resource allocation, increase farmers' incomes, and improve the overall efficiency of the agricultural sector. Therefore, this study conducted a comprehensive search of government websites, including those of the State Council, the National Development and Reform Commission, the Ministry of Natural Resources, the Ministry of Agriculture and Rural Affairs, the Ministry of Ecology and Environment, and the Ministry of Finance, using keywords such as "land," "crops," "agriculture," and "cropping structure." A total of 171 policies related to crop structure optimization and cultivated land protection, which have contributed to adjusting crop structures since 2003, were systematically reviewed. Based on the four representative policy selection criteria mentioned earlier, eight policies that are more comprehensive and representative were selected for empirical analysis. From 2003 to 2024, the eight representative policies encompass various aspects, including agricultural structure adjustment, agricultural subsidies, and cultivated land protection. It provides detailed information on the specific names of these representative policies, their issuing agencies, publication dates, core viewpoints, and the rationale for their selection in Table 1.

TABLE 1 Sample policies for PMC-Index model.

Item	Policy name	Publishers	Release time	Core viewpoint	Reason
POL1	National Regional Layout Plan of Advantageous Agricultural Products (2008–2015)	Ministry of Agriculture of the PRC	September, 2008	The dominant areas of grain crop production in China were identified (Meng & Xu, 2023).	As a planning document, it provided a comprehensive framework for optimizing the geographical layout of agricultural production, serving as a practical example of regional strategic adjustments in agriculture.
POL2	Guidance on further adjustment and optimization of the agricultural structure	Ministry of Agriculture of the PRC	January, 2015	For the first time, the "conversion of grain crops to fodder crops" was proposed as an important reform of China's planting structure. For three consecutive years, it was taken as an important initiative to promote the optimization of agricultural production methods.	It played an exploratory role in promoting the diversified use of grain crops, reflecting the direction of agricultural supply-side structural reform. It represents an initial attempt to transition China's agricultural structure from a focus on grain production to cash and feed crops.
POL3	Guidance on adjusting and improving the policy of three agricultural subsidies	Ministry of Finance of the PRC、Ministry of Agriculture of the PRC	May, 2015	China's grain cultivation subsidies have been adjusted for the first time since 2003 to integrate direct grain subsidies, comprehensive subsidies for production materials and good seed subsidies into agricultural protection subsidies to support cultivated land conservation and grain production capacity enhancement.	It represented a significant adjustment in China's agricultural subsidy system, improving the targeting and effectiveness of subsidies through resource integration. This marks an important step toward the gradual development of China's agricultural subsidy policy, with a focus on sustainability and equity.
POL4	Several opinions on the implementation of the new concept of development to accelerate the modernization of agriculture to achieve the goal of overall well-off	Communist Party of China Central Committee、State Council of the PRC	December, 2015	For the first time, agricultural supply-side reform was written into the national document, focusing on the issue of agricultural structure and efficiency.	This policy played a crucial role in comprehensively advancing agricultural modernization in China, aligning it with the national socio-economic development strategy. It marks a shift in China's agricultural policy toward modernization and high-quality development.
POL5	National Plan for the Restructuring of the Plantation Industry (2016–2020)	Ministry of Agriculture of the PRC	April, 2016	The tasks of structural adjustment of China's planting industry in the "13th Five-Year Plan" period were to build a crop structure with coordinated development of grain crops, cash crops and fodder crops, a variety structure that adapts to market demand, a regional layout with coordinated production and ecology, and a farming system that combines land use and land raising (Drew et al., 2011).	It represented China's strategic approach to crop structure adjustment during the "13th Five-Year Plan" period, focusing on diversifying agricultural products and aligning with market demand. This reflects a shift in agricultural production from a yield-driven approach to one focused on efficiency.
POL6	Notice on the issuance of exploring the implementation of cultivated land rotation fallow system pilot program	Ministry of Agriculture of the PRC	June, 2016	The implementation of crop rotation was an important measure to optimize the crop cultivation structure, which was an important symbol of the shift of cultivated land protection to the integrated management of quantity, quality and ecology (Gong, 2018).	It represents the nation's efforts in protecting cultivated land in terms of quantity, quality, and ecology, emphasizing the shift toward a green and sustainable agricultural production approach.

(Continued)

TABLE 1 (Continued)

Item	Policy name	Publishers	Release time	Core viewpoint	Reason
POL7	Notice on the issuance of the "Soybean Revitalization Program Implementation Plan"	Office of the Ministry of Agriculture of the PRC	March, 2019	The restructuring of the cropping industry in China to adapt to the changes in the main social contradictions and the implementation of the food safety strategy.	This is a key support policy for the production of major oilseed crops in China, carrying strategic significance.
POL8	Opinions on the prevention of cultivated land "non-food" to stabilize food production	Office of the State Council	November, 2020	An important initiative made to prevent agricultural restructuring from depressing food production and reducing invisible losses in food productivity (Wang et al., 2023).	It reflects the nation's emphasis on mitigating the risks associated with the deviation of cultivated land from grain production, aiming to safeguard grain production capacity and demonstrating a strong commitment to food security.

3.2 Methods

This study employed text mining techniques and the PMC-Index model, as these methods are effective in quantifying and evaluating the logic, comprehensiveness, and sustainability of policy texts. Text mining is widely used in policy research, offering a way to analyze government policy behavior and extract valuable insights into policy positions and tendencies through the examination of content. Compared to other evaluation methods, the PMC-Index model minimizes human subjectivity by employing a multidimensional evaluation system, thus enhancing the scientific rigor and objectivity of the results (Dai et al., 2021). The model assumes a universal relationship between elements and treats the variables within the policy as equally significant (Ruiz Estrada et al., 2007). The primary variables are determined by the policy's attributes and objectives, with sub-variables providing further definition. Building the PMC-Index model operationally involves four distinct processes: classifying variables and identifying parameters, constructing an input–output table, calculating the PMC index, and generating the PMC surface.

3.2.1 Text mining

Text mining is the process of extracting valuable information from unstructured text. By using natural language processing (NLP) algorithms, text mining enables the quantitative analysis of text based on predefined criteria, reducing human bias in the process. Techniques like word frequency analysis and topic modeling can reveal hidden patterns and trends within the text. Policy documents hold vast amounts of critical information, which is closely tied to their effectiveness. Therefore, this study employs text mining within identify key information in crop structure optimization policies.

We integrated 171 policy documents related to crop structure optimization and cultivated land protection issued after 2003. Terms expressing degree, modifiers, and irrelevant words-such as "strengthen," "strictly prohibit," and "establish"-were removed. The documents were imported into Nvivo12 software for segmentation and word frequency analysis. Redundant or semantically similar terms (e.g., "adjustment" and "optimization," "farmers" and "villagers") were merged. High-frequency words were extracted from the text, and a word cloud focused on crop structure optimization policies was generated (Figure 1). The font size in the figure reflects the frequency of these terms. "Cultivated land" and "grain" were the most frequently mentioned elements in policy implementation, prominently displayed at the center of the figure. As we can see, the policy documents consistently highlight the importance of production, construction, and development in policy formulation. Policies from the State Council on cultivated land protection and agricultural structural adjustment emphasize grain production, resource optimization, and the preservation of permanent basic farmland. The key stakeholders include enterprises, the government, farmers, and other relevant groups. The core objective of these policies is to strengthen cultivated land protection and ensure grain security.

3.2.2 PMC-Index model variable settings

The development of the crop planting structure optimization policy evaluation system (Table 2) was informed by an analysis of the word cloud generated from the optimization policies, along with findings from existing literature (Xiong et al., 2023; Zhang & Geng, 2015). This evaluation system was built by integrating the specific principles of the PMC-Index model.

The study constructed a crop structure optimization policy evaluation system with ten first-level variables. These variables were policy aim (P_1), policy nature (P_2), issuing agency (P_3), effectiveness level (P_4), policy area (P_5), policy guarantee (P_6), policy object (P_7), policy function (P_8), incentive means (P_9), and policy disclosure (P_{10}). According to existing research (Zhu & Lu, 2022), ten policy factors were examined to assess the quality and effectiveness of policy in optimizing crop cultivation structure. The content assessment covered five key aspects: consistency of policy formulation with current issues, detailed policy planning, scientifically sound policy programs, specific policy objectives, and complete policy safeguards. The first four factors, P_1, P_2, P_3, and P_4, assessed the basic characteristics of the policy. In addition, the remaining factors, P_5, P_6, P_7, P_8, and P_9, focused on assessing policy effectiveness in optimizing crop cultivation structure. The secondary variables were assigned to their respective primary variables, resulting in 39 secondary variables.

3.2.3 Create multiple input–output tables

The multi-input–output table served as the fundamental analytical for computing the PMC index of the policy aimed at optimizing the

FIGURE 1
Word cloud of crop planting structure optimization policies.

crop planting structure. The fundamental contents of the PMC-Index model served as a guide for creating the multi-input–output table in this research (Table 3). The variable system was designed based on these principles, consisting of 10 primary and 39 subsidiary variables. Equal weights were assigned to all variables in the evaluation system.

3.2.4 PMC-Index calculation

The calculation of the PMC-Index involved a four-step process. Firstly, the primary and secondary variables developed for this research were incorporated in a multi-input–output table. Secondly, the values of the secondary variables were determined using Equations 1, 2. Subsequently, the values of the primary variables were calculated based on Equation 3. Finally, the PMC-Index was computed by aggregating the primary variables according to Equation 4.

$$P : N\left[0 \sim 1\right] \tag{1}$$

$$P = \left\{PR : \left[0 \sim 1\right]\right\} \tag{2}$$

$$P_i = \sum_{j=1}^{n} \frac{P_{ij}}{T\left(P_{ij}\right)} \tag{3}$$

$$PMC\ Index = \sum_{i=1}^{10}\left(P_i\left[\sum_{j=1}^{n}\frac{P_{ij}}{T\left(P_{ij}\right)}\right]\right) \tag{4}$$

Where i is the main-variable, $i = 1,2,3,\cdots,m$. j is the sub-variable, $j = 1, 2,\cdots,n$. T is the number of the total sub-variables in analysis.

Using variable standardization at all levels, the content analysis and binary counting methods were applied to complete calculations for the eight selected policies. If the policy conformed to one of the second-level variables, it was coded as 1; otherwise, it was coded as 0.

Dividing the values of the main variables P_1 and P_4 by the number of their respective sub-variables was necessary, as these sub-variables were mutually exclusive (Wu & Shen, 2021). Specifically, the value for P_1 should be divided by 0.33, while the value for P_4 should be divided by 0.25. Additionally, it was essential to note that the range of values for the remaining eight first-order variables should adhere to the condition $P_i \leq 1$. This research categorized the PMC-Index of the crop planting structure optimization strategy into four levels of consistency, as demonstrated by previous research conducted by Ruiz Estrada (Ruiz Estrada et al., 2007; Ruiz Estrada, 2011) (Table 4). In particular, the policy evaluated was low-consistent if the PMC-Index score was between 0 and 4.99. It was an acceptable consistency policy if the score was between 5 and 6.99. It was a good consistency policy if the score was between 7 and 8.99. It was a perfect consistency policy if the score

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TABLE 2 Variables setting of quantitative evaluation of crop structure optimization policy.

Main-variables	Item	Sub-variables	Item
Policy aim	P_1	Long-term goals (more than 5 years)	P_{1-1}
		Mid-term goals (1–5 years)	P_{1-2}
		Immediate goals (within 1 year)	P_{1-3}
Policy nature	P_2	Projection	P_{2-1}
		Regulation	P_{2-2}
		Recommendation	P_{2-3}
		Introduction	P_{2-4}
Issuing agency	P_3	Standing Committee of the National People's Congress	P_{3-1}
		Communist Party of China Central Committee	P_{3-2}
		State Council	P_{3-3}
		Ministry of Natural Resources of the PRC / Ministry of Agriculture of the PRC	P_{3-4}
		Other Ministries of the PRC	P_{3-5}
Effectiveness level	P_4	Law	P_{4-1}
		Administrative regulations	P_{4-2}
		Regulations of the Communist Party of China	P_{4-3}
		Normative documents	P_{4-4}
Policy area	P_5	Economy	P_{5-1}
		Societal	P_{5-2}
		Environment	P_{5-3}
		Institution	P_{5-4}
		Technology	P_{5-5}
Policy guarantee	P_6	Legal guarantee	P_{6-1}
		Performance assessment	P_{6-2}
		Supervision and inspection	P_{6-3}
		Financial support	P_{6-4}
		Pilot projects	P_{6-5}
		Publicity and education	P_{6-6}
Policy object	P_7	Governments at all levels	P_{7-1}
		Social forces	P_{7-2}
		Village organizations	P_{7-3}
		Farmers	P_{7-4}
Policy function	P_8	Sound supporting other policies	P_{8-1}
		Stabilization of food production	P_{8-2}
		Meeting development needs	P_{8-3}
		Improving the quality of cultivated land	P_{8-4}
		Protecting the ecological environment	P_{8-5}
Incentive means	P_9	Giving financial assistance	P_{9-1}
		Giving land indicators	P_{9-2}
		Other ways	P_{9-3}
Policy disclosure	P_{10}	–	–

was between 9 and 10. A higher PMC score indicated greater comprehensiveness in the policy and practical applicability in implementing the policy.

3.2.5 PMC surface drawing

The surface diagram can more intuitively present the performance of the policy in all dimensions. The concave and convex situation and

TABLE 3 A multi-input–output table for policy evaluation of crop structure optimization.

Main-variables	Sub-variables
P_1	P_{1-1}, P_{1-2}, P_{1-3}
P_2	P_{2-1}, P_{2-2}, P_{2-3}, P_{2-4}
P_3	P_{3-1}, P_{3-2}, P_{3-3}, P_{3-4}, P_{3-5}
P_4	P_{4-1}, P_{4-2}, P_{4-3}, P_{4-4}
P_5	P_{5-1}, P_{5-2}, P_{5-3}, P_{5-4}, P_{5-5}
P_6	P_{6-1}, P_{6-2}, P_{6-3}, P_{6-4}, P_{6-5}, P_{6-6}
P_7	P_{7-1}, P_{7-2}, P_{7-3}, P_{7-4}
P_8	P_{8-1}, P_{8-2}, P_{8-3}, P_{8-4}, P_{8-5}
P_9	P_{9-1}, P_{9-2}, P_{9-3}
P_{10}	P_{10}

TABLE 4 Policy level classification.

PMC index	[9, 10]	[7, 8.99]	[5, 6.99]	[0, 4.99]
Evaluation	Perfect	Good	Acceptable	Low

the surface's average concave and convex degree can reflect the policy's internal consistency and reasonable structure levels. PMC surface is a 3-dimensional spatial surface composed of a 3 × 3 matrix. Since this study collects data on public policies, the policy disclosure indicators (P_{10}) related only to the first level of variables, and the variable value was 1. Considering the symmetry of the PMC matrix and the surface balance, P10 was excluded to import the remaining nine first-level index Equation 5 to form the 3 × 3 matrix.

$$PMC\ Surface = \begin{bmatrix} P_1 & P_2 & P_3 \\ P_4 & P_5 & P_6 \\ P_7 & P_8 & P_9 \end{bmatrix} \quad (5)$$

4 Results

4.1 PMC-Index calculation of policy samples

The policy samples were parameterized using text-mining techniques, and the PMC-Index for each sample was calculated using Equations 1–4, alongside the input–output tables (Table 5). The policy grade for each sample was then determined according to the principles outlined in Table 2.

As shown in Table 6, seven policies were rated as acceptable, while one was categorized as low. Overall, the PMC-Index for the eight policy samples displayed a steady upward trend, increasing from 4.88 to 6.61 over time. This reflects a positive development in China's crop planting structure policy, evidenced by clearer policy objectives, more comprehensive policy frameworks, a broader range of issuing bodies, wider policy domains, strengthened policy safeguards, comprehensive coverage of target groups, and greater specificity in policy functions.

Over time, the policy has been dynamically adjusted to respond to changes in agricultural development and market demands, particularly in areas such as structural adjustments, subsidy optimization, and the modernization of agriculture. The rising PMC-Index suggests a gradual improvement in the quality and effectiveness of policy formulation. However, the analysis also highlights areas for improvement, such as a lack of diversity in incentive mechanisms and inconsistencies in certain policies.

From a PMC-Index classification perspective, most policies exhibit a high level of consistency, but some underperform in critical areas like incentive mechanisms and inter-departmental coordination, indicating the need for further refinement. Strengthening these aspects is essential for enhancing policy effectiveness and ensuring food security. This includes ensuring that policies comprehensively address all stakeholders, effectively integrate resources, and offer targeted solutions to key challenges.

In conclusion, while China's policies have made significant progress in promoting food security and sustainable agricultural development, further optimization is necessary to improve policy comprehensiveness, coordination, and incentive mechanisms. This will be key to achieving more efficient and sustainable agricultural development in the future.

4.2 PMC surface mapping of policy samples

The construction of the PMC matrix for the policy sample was based on the calculation of the PMC-Index and the application of Equation 5 (Table 7). From this, the PMC surface of the policy and the average PMC surface were plotted. The numerical labels 1, 2, and 3 in the figure correspond to the horizontal coordinates of the matrix, while series 1, 2, and 3 represent the vertical values. Different colored blocks indicate varying scores across different variables. The strength of the policy dimensions was assessed based on the curvature of the surfaces: convex surfaces indicate higher scores for the corresponding level 1 variables, while concave surfaces suggest lower scores (Figure 2).

To evaluate the composite score of each crop structure optimization policy, a heat map was created to represent the

TABLE 5 The multi-input/output matrix of eight policies.

Main-variables	Sub-variables	POL1	POL2	POL3	POL4	POL5	POL6	POL7	POL8
P_1	$P_{1\text{-}1}$	1	1	1	0	0	0	1	1
	$P_{1\text{-}2}$	0	0	0	1	1	1	0	0
	$P_{1\text{-}3}$	0	0	0	0	0	0	0	0
P_2	$P_{2\text{-}1}$	1	0	0	1	1	1	1	0
	$P_{2\text{-}2}$	0	1	1	1	0	1	0	1
	$P_{2\text{-}3}$	1	1	1	1	1	1	1	1
	$P_{2\text{-}4}$	1	1	1	1	1	1	1	1
P_3	$P_{3\text{-}1}$	0	0	0	0	0	0	0	0
	$P_{3\text{-}2}$	0	0	0	1	0	0	0	0
	$P_{3\text{-}3}$	0	0	0	1	0	0	0	0
	$P_{3\text{-}4}$	1	1	1	0	1	1	1	0
	$P_{3\text{-}5}$	0	0	1	0	0	1	0	1
P_4	$P_{4\text{-}1}$	0	0	0	0	0	0	0	0
	$P_{4\text{-}2}$	0	0	0	0	0	0	0	0
	$P_{4\text{-}3}$	0	0	0	1	0	0	0	0
	$P_{4\text{-}4}$	1	1	1	0	1	1	1	1
P_5	$P_{5\text{-}1}$	1	1	1	1	1	1	1	1
	$P_{5\text{-}2}$	1	1	1	1	1	1	1	1
	$P_{5\text{-}3}$	1	1	0	0	1	1	1	0
	$P_{5\text{-}4}$	1	1	1	0	1	1	1	1
	$P_{5\text{-}5}$	1	1	0	0	1	1	1	1
P_6	$P_{6\text{-}1}$	0	0	0	0	0	0	0	1
	$P_{6\text{-}2}$	0	0	0	1	0	0	0	1
	$P_{6\text{-}3}$	0	0	1	1	0	1	0	1
	$P_{6\text{-}4}$	1	1	0	0	1	1	1	1
	$P_{6\text{-}5}$	0	1	1	1	1	1	1	0
	$P_{6\text{-}6}$	0	1	1	0	0	1	1	0
P_7	$P_{7\text{-}1}$	1	1	1	1	1	1	1	1
	$P_{7\text{-}2}$	0	1	1	1	1	0	1	1
	$P_{7\text{-}3}$	0	1	0	1	1	1	1	1
	$P_{7\text{-}4}$	0	1	1	1	1	1	1	1
P_8	$P_{8\text{-}1}$	0	1	1	0	1	1	1	1
	$P_{8\text{-}2}$	1	1	1	0	1	0	1	1
	$P_{8\text{-}3}$	1	1	0	1	1	0	1	1
	$P_{8\text{-}4}$	0	0	0	0	1	1	1	0
	$P_{8\text{-}5}$	1	1	0	0	1	1	1	0
P_9	$P_{9\text{-}1}$	1	0	1	0	1	1	1	1
	$P_{9\text{-}2}$	0	0	0	0	0	0	0	1
	$P_{9\text{-}3}$	0	1	0	0	1	0	0	1
P_{10}		1	1	1	1	1	1	1	1

scores of the eight policy samples across different dimensions (Figure 3). The heat map shows that the eight policies achieved similar scores in policy aim (P_1), effectiveness level (P_4), and policy disclosure (P_{10}), but displayed significant variation in other dimensions.

Policy nature (P_2) refers to several functions of a policy, including prediction, regulation, counseling, and guidance. The optimization of crop planting structures involves setting target expectations for crop yields and other indicators, advising and guiding local areas to actively optimize their planting structures, and adopting effective supervisory

TABLE 6 PMC-Index and grade of policy samples.

Main-variables	POL1	POL2	POL3	POL4	POL5	POL6	POL7	POL8	AVG
P_1	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
P_2	0.75	0.75	0.75	1	0.75	1	0.75	0.75	0.81
P_3	0.2	0.2	0.4	0.4	0.2	0.4	0.2	0.2	0.28
P_4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
P_5	1	1	0.6	0.4	1	1	1	0.8	0.85
P_6	0.17	0.51	0.51	0.51	0.34	0.68	0.51	0.68	0.49
P_7	0.25	1	0.75	1	1	0.75	1	1	0.84
P_8	0.6	0.8	0.4	0.2	1	0.6	1	0.6	0.65
P_9	0.33	0.33	0.33	0	0.66	0.33	0.33	1	0.41
P_{10}	1	1	1	1	1	1	1	1	1
PMC-Index	4.88	6.17	5.32	5.09	6.53	6.34	6.37	6.61	5.91
Number	8	5	6	7	2	4	3	1	/
Evaluation	Low	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	/

TABLE 7 The PMC-Matrix of eight policy samples.

Policy	POL1	POL2	POL3	POL4
PMC-Matrix	$\begin{bmatrix}0.330.250.25\\0.751.000.60\\0.200.170.33\end{bmatrix}$	$\begin{bmatrix}0.330.251.00\\0.751.000.80\\0.200.510.33\end{bmatrix}$	$\begin{bmatrix}0.330.250.75\\0.750.600.40\\0.400.510.33\end{bmatrix}$	$\begin{bmatrix}0.330.251.00\\1.000.400.20\\0.400.510.00\end{bmatrix}$

Policy	POL5	POL6	POL7	POL8
PMC-Matrix	$\begin{bmatrix}0.330.251.00\\0.751.001.00\\0.200.340.66\end{bmatrix}$	$\begin{bmatrix}0.330.250.75\\1.001.000.60\\0.400.680.33\end{bmatrix}$	$\begin{bmatrix}0.330.251.00\\0.751.001.00\\0.200.510.33\end{bmatrix}$	$\begin{bmatrix}0.330.251.00\\0.750.800.60\\0.200.681.00\end{bmatrix}$

measures to ensure policy implementation. In this dimension, the lowest score was 0.75, the highest was 1, and the average score was 0.81—all of which indicate a high level of performance. This demonstrates that China's crop planting structure optimization policies have a strong and comprehensive understanding of the direction and effects of policy implementation.

The administrative level and management scope of the issuing agency (P_3) directly influence the efficiency of policy implementation. During the research period, China's crop planting structure optimization policies were primarily issued individually or jointly by the National People's Congress (NPC), the Central Committee of the Communist Party of China (CPC), the State Council (SC), the Ministry of Agriculture and Rural Affairs (MOA), and the Ministry of Natural Resources (MNR). Since 2003, the MOA has been the main issuing agency for these policies, with inter-departmental communication and collaboration playing a critical role in policy formulation and implementation. As a result, there was a gradual diversification of issuing agencies for POL3 and POL4, which indirectly expanded the scope of the policies. However, in later stages, to enhance the relevance and operationalization of the policies and improve implementation efficiency, the number of issuing agencies was reduced, leading to decreased communication between government departments. Consequently, the scores for the issuing agencies of POL7 and POL8 were lower.

Policy area (P_5) defines the scope of a policy's impact. The higher scores for POL1, POL2, POL5, POL6, and POL7 in this research indicate that these five policies have a more comprehensive influence across economic, social, environmental, institutional, technological, and other sectors. POL4, with the lowest score of 0.4, reflects limited coverage, focusing only on economic and social areas. Overall, the average score for the policy area dimension was 0.85, suggesting that China's crop structure optimization policies are likely to have a significant impact on the implementation process.

Policy safeguards (P_6) refer to the supporting mechanisms and institutions that ensure effective and efficient policy implementation. The policy safeguards highlighted in this research include various strategies, such as legal frameworks, performance evaluation, supervision and inspection, financial support, pilot projects, and public awareness and education initiatives. The overall increase in scores for the policy safeguards dimension from POL1 to POL8 reflects China's significant progress since 2003 in strengthening and refining policies to improve the efficiency of crop structure optimization. The later policies show a higher level of guarantees and stricter supervision, providing a strong foundation for ensuring food security.

Policy object (P_7) consists of two components: the subject of policy implementation and the object of policy implementation. In China, various levels of government play key roles in policy execution. The number of implementing agencies and the degree of departmental

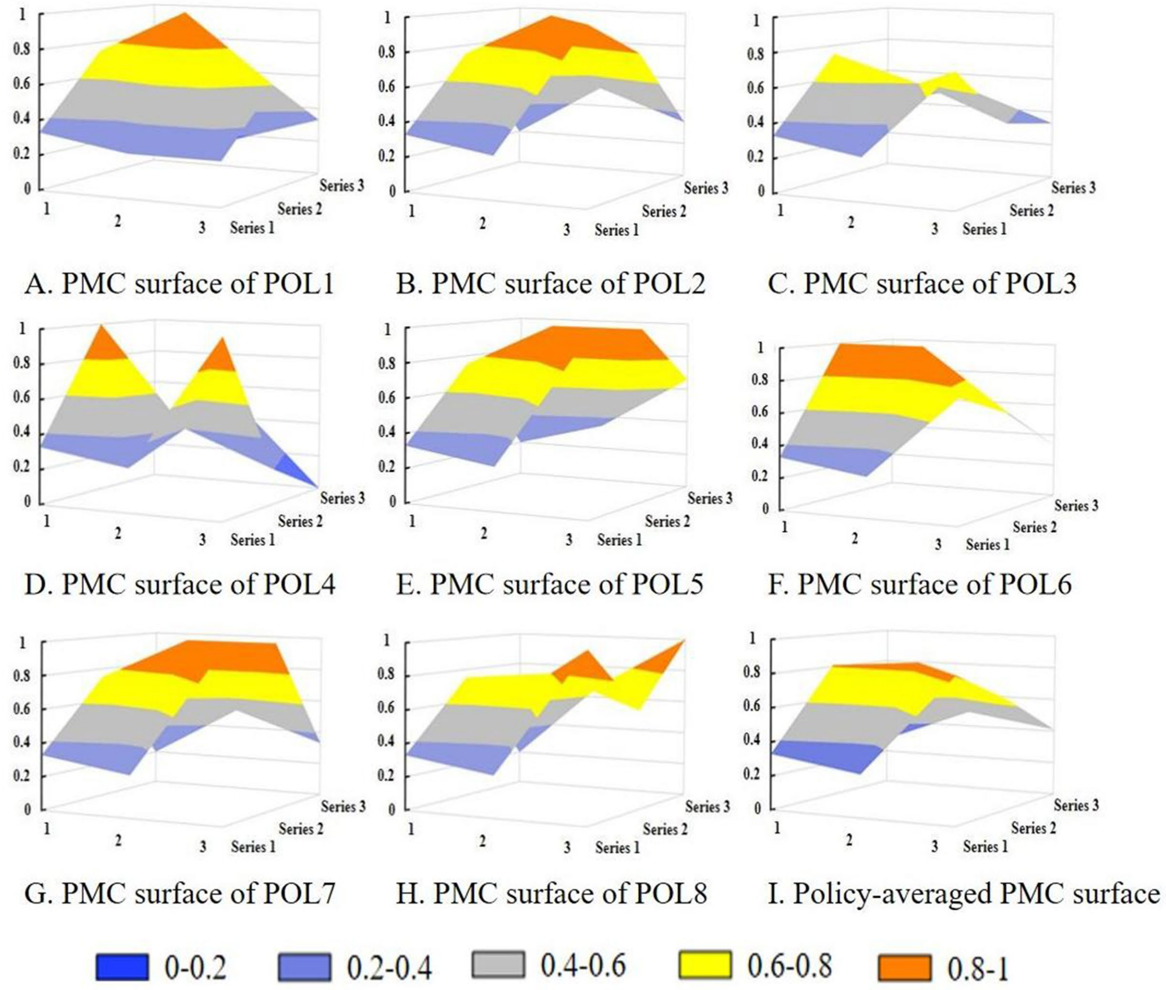

FIGURE 2
PMC Surface of policies.

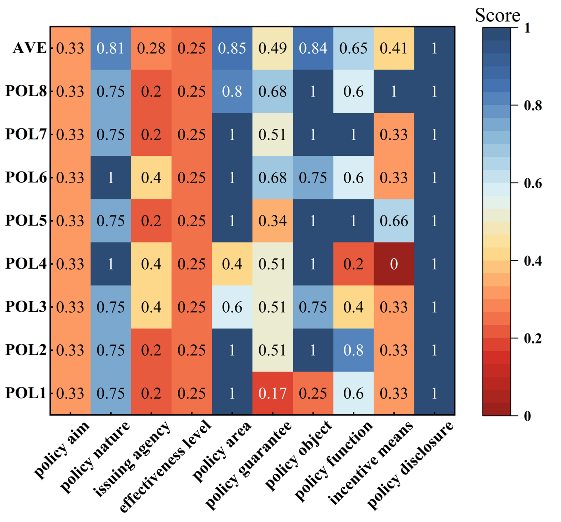

FIGURE 3
Scores of each dimension for policies.

coordination directly impact the effectiveness of policy implementation. Policy implementation objects include lower levels of government, social organizations, and farmers. The study found that the average score for the policy object dimension was 0.84, indicating that policy formulation encompassed a wide range of implementation subjects and covered the necessary implementation objects. POL1 scored lower in this dimension, as it primarily targeted the agriculture and rural sectors of provinces, autonomous regions, and municipalities directly under the central government. In contrast, policies like POL4 and POL8 had broader objectives, focusing on social forces, village-level organizations, and farmers, including family farms and large grain producers. The diversification of policy objects has resulted in the gradual decentralization of government power and increased motivation and participation among other stakeholders.

P_8 represents "policy function," which refers to a policy's inherent characteristics, its implementation goals, and its potential effects during execution. In 2017, the Chinese government introduced a new concept of joint protection of cultivated land in terms of quantity, quality, and ecology, referred to as the "trinity." The primary aim of this concept was to maintain the quantity of cultivated land by enhancing its quality to boost food production and protect the cultivated land ecosystem. Given the close relationship between crop cultivation and cultivated land, this study argues that crop structure optimization policy objectives should encompass the following dimensions: (1) Providing complementary support to existing cultivated land protection policies; (2) Stabilizing the quantity of cultivated land to ensure stable food production; (3) Improving the quality of cultivated land to increase its production capacity; (4) Preserving the stability of cultivated land ecosystems to protect the natural environment; and (5) Meeting development requirements. The average score for the policy function dimension was 0.65, suggesting that while China's crop structure optimization policies are relatively comprehensive, there is still room for improvement. POL4 scored lower in this dimension because it primarily focused on meeting development requirements, while later policies emphasized the ecological protection function. Additionally, POL8 embodied the function of effectively supporting established policies. This indicates that the policy system for optimizing crop planting structure is gradually taking shape, with ecological protection becoming a key element in policy formulation and implementation (Liu & Zhao, 2022).

Incentive means (P_9) refer to the government's measures and methods for encouraging policy recipients to actively participate in policy implementation. From a comprehensive analysis of the relevant policy texts, financial subsidies emerged as the most important incentive tool. The average score for this policy dimension was 0.41, indicating that the incentive methods in the relevant policies are relatively limited. For example, POL4 did not specify any incentives, resulting in the lowest score. In contrast, POL8 received the highest score due to its proactive promotion of incentives, including the allocation of agricultural funds, support for socialized agricultural production services, and the implementation of food subsidies. Overall, the Chinese government has been gradually developing a multi-level and diversified incentive mechanism to support the structural transformation of crop cultivation, in line with the evolving demands for food production and the supply of key agricultural products.

5 Discussion

5.1 Impact of crop planting structure optimization food security

Crops encompass both food crops and cash crops, and changes in the planting ratios of these crops can, to some extent, reflect the effectiveness of crop structure optimization policies. To evaluate this, we conducted a systematic analysis of the changes in the planting ratios of food and cash crops across 31 provinces and municipalities in China (excluding Hong Kong, Macau, and Taiwan) from 2003 to 2022 (Figures 4, 5). This analysis aims to highlight the impact of policy implementation on crop planting structures and provide insights into how these policies have shaped agricultural production across different regions.

The overall trend in China's crop planting structure reveals a steady increase in the proportion of food crops, coupled with a continuous decline in the proportion of cash crops. This shift reflects China's ongoing efforts to ensure food security and enhance food self-sufficiency. The significant rise in the proportion of food crops between 2008 and 2010 may be linked to heightened concerns over global food crises and domestic food security challenges. After 2014, the proportion of food crops stabilized further, while the share of cash crops declined to relatively low levels.

The introduction of the National Regional Layout Plan of Advantageous Agricultural Products (2008–2015) had a profound impact on the northeastern and northern regions of China. As major grain-producing areas, these regions received increased policy support

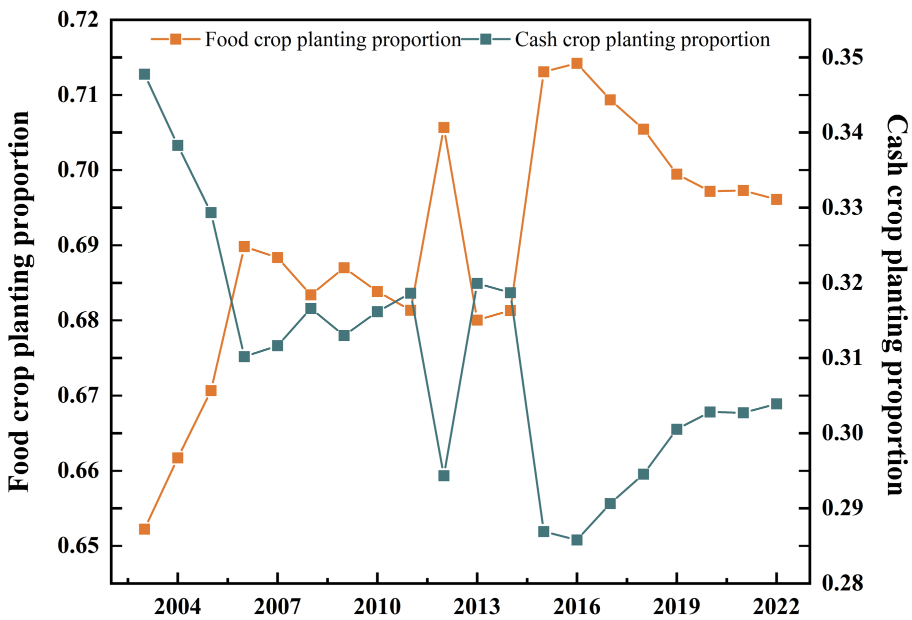

FIGURE 4
Changes in the planting ratios of grain crops and cash crops in China from 2003 to 2022.

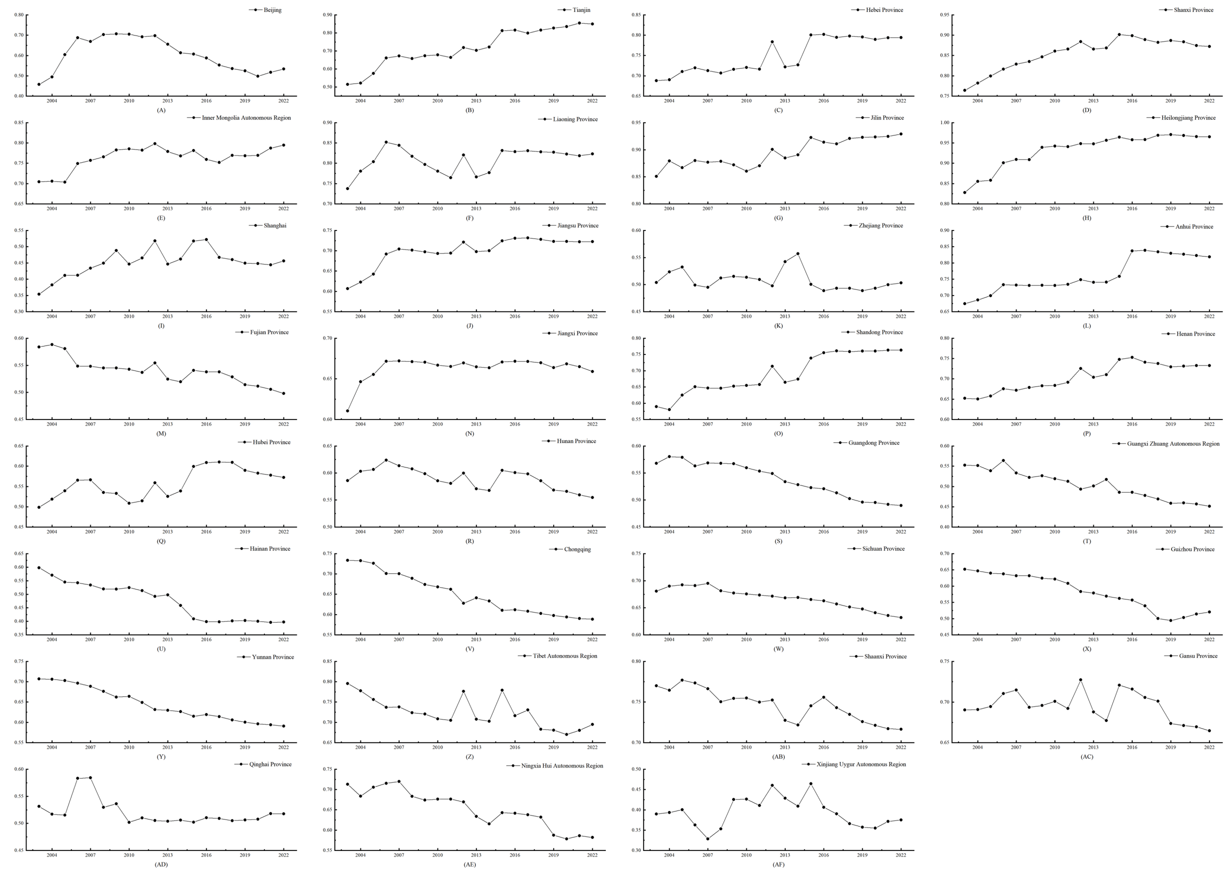

FIGURE 5
Changes in the planting ratios of grain crops across China's provinces from 2003 to 2022.

and financial investment, resulting in a significant rise in grain cultivation, particularly in provinces like Heilongjiang, Jilin, and Liaoning. The implementation of the plan fostered the scale and intensive development of grain production in these regions. In contrast, economically developed coastal provinces, such as Jiangsu and Zhejiang, were encouraged to focus on cultivating specialized cash crops, including tea and vegetables.

The introduction of several policies in 2015 further accelerated the adjustment of planting structures across various regions. The modification of agricultural subsidy policies was particularly effective in major grain-producing areas, leading to a further increase in the proportion of food crop cultivation in provinces like Heilongjiang and Jilin. This highlights the positive role these policies played in enhancing food security. In contrast, regions with a higher proportion of cash crop cultivation, such as Jiangsu and Guangdong, were less affected by these policy adjustments, indicating that the primary focus remained on promoting grain production.

The implementation of the National Plan for the Restructuring of the Plantation Industry (2016–2020) produced varied outcomes across different provinces. In major grain-producing regions, such as Northeast and North China, the proportion of food crop cultivation remained high, indicating that structural adjustments were mainly aimed at enhancing the quality and efficiency of grain production. In contrast, economically developed coastal provinces saw increased diversification and efficiency in cash crop cultivation. Additionally, the introduction of the crop rotation and fallow system improved soil quality in regions like Heilongjiang and Jilin, resulting in further increases in both the yield and quality of grain (Yang et al., 2020). In some areas, the rotation and fallow system also facilitated planting structure adjustments by reducing the cultivation of less efficient food crops.

The implementation of the Soybean Revitalization Program Implementation Plan in 2019 significantly increased the soybean planting area in provinces like Heilongjiang. In some regions, crop rotation practices were employed to enhance both the yield and quality of soybeans (Yang et al., 2024b). However, the overall impact of this policy on the proportion of food crop cultivation remained relatively limited.

Following the introduction of the Opinions on the Prevention of Cultivated Land "Non-Food" to stabilize food production in 2020, the proportion of food crop cultivation was further consolidated across provinces, particularly in some non-traditional grain-producing areas. The policy encouraged some farmers to return to growing food crops, effectively curbing the trend of converting cultivated land to non-food use.

Overall, China's crop structure optimization policies have been successful in ensuring food security, strengthening farmland protection, promoting agricultural modernization, and fostering sustainable development. These policies have not only enhanced the stability and sustainability of food production but also provided strong support for the diversification and increased efficiency of cash crop development.

5.2 Improvement pathways for policies

Optimizing crop planting structure is a vital strategy for strengthening the protection of cultivated land resources and ensuring food security. However, the research findings reveal certain deficiencies in the formulation of relevant policies, indicating that there is still room for improvement in policy design.

5.2.1 Develop flexible and diverse incentives

Current policies primarily rely on fiscal subsidies, but the incentive measures are relatively narrow, leading to limited policy effectiveness, especially with low scores in terms of diversity and sustainability. The average score of the eight policies was only 0.41. Therefore, it is recommended to introduce a broader range of incentives, such as tax reductions, low-interest loans, ecological compensation, and agricultural insurance, to help mitigate the financial risks faced by farmers and agricultural enterprises, thereby enhancing their participation and engagement. Building on the successful experiences in the northeastern and northern grain-producing regions, policies in these areas should further strengthen subsidies and introduce ecological compensation and technology application subsidies. These would encourage the adoption of water-saving and environmentally friendly technologies, thereby enhancing the overall effectiveness of policy implementation (Liu et al., 2020).

5.2.2 Enhance interdepartmental collaboration

Research showed that insufficient interdepartmental coordination hinders the effective implementation of policies, particularly in POL2, POL7, and POL8, where cross-departmental collaboration scores were notably low. Given the varying effects of policies across regions, it is recommended to establish mechanisms for interdepartmental collaboration, such as regular joint meetings or dedicated working groups, to ensure effective information sharing and resource coordination among departments. In major grain-producing regions and economically developed areas, strengthening cross-departmental collaboration and feedback mechanisms is crucial for enabling dynamic policy adjustments. Additionally, local governments should be encouraged to engage in horizontal cooperation, sharing experiences and resources to achieve complementary and synergistic policy outcomes, particularly in promoting specialized economic crops. Meanwhile, a feedback mechanism should be established to ensure the dynamic adjustment of policies.

5.2.3 Expand policy coverage

Some policies have limited implementation scopes and fail to fully benefit all target groups, particularly in terms of economic and social performance. For instance, the scope of POL4 scored only 0.4 points. It is recommended to involve a broader range of stakeholders, including cooperatives, agricultural enterprises, and research institutions, in policy implementation to leverage their expertise and resources and expand the policy's impact. In ecologically vulnerable and economically underdeveloped regions, policies should provide more targeted support to promote balanced regional development. Additionally, increasing the involvement of grassroots organizations and farmers' cooperatives would enable policies to reach deeper into local communities, directly benefiting a larger number of farmers (Yang et al., 2024a).

5.2.4 Enhance policy function comprehensiveness

Although current policies cover cultivated land protection, yield improvement, and environmental protection, there is still room for improvement in their comprehensiveness. For example, POL2 does not effectively address specific measures for improving cultivated land quality, while POL3, POL6, and POL8 lack sufficient focus on protecting the ecological environment of cultivated land. The functional score of POL4 is only 0.2, as it primarily focuses on protecting the quantity of cultivated land rather than addressing broader issues. Based on policy implementation outcomes, it is recommended to further refine policy objectives to ensure they encompass the stabilization of farmland quantity, improvement of farmland quality, and protection of ecosystems. Additionally, establishing clear quantitative indicators would facilitate more effective post-implementation evaluation and adjustment. Specific ecological protection measures, such as crop rotation, fallow practices, and the promotion of organic agriculture, should also be incorporated to ensure the sustainability of agricultural production. Moreover, enhancing the dynamic adjustment capacity of policies will enable timely modifications in response to changes in farmland conditions and market demands (Ou & Feng, 2019).

5.2.5 Improve policy safeguards

While significant progress has been made in recent years, there remains a need for further enhancement in areas such as supervision, evaluation, and legal safeguards, such as POL1, POL4, POL6, and POL8. To address the differential effects of policy implementation, it is recommended to establish a rigorous performance evaluation system that regularly assesses policy outcomes. Based on these evaluations, adjustments should be made to ensure the effectiveness and sustainability of the policies. Strengthening the legal framework is also essential, providing legal support for policy enforcement and clearly defining responsibilities for non-compliance. Additionally, increasing transparency and public participation is crucial, especially in major grain-producing regions and economically developed areas. This can be achieved through improved policy communication and information disclosure, which would raise public awareness, foster greater involvement, and create a societal environment of shared support and supervision for policy implementation.

5.2.6 Intensify technological support

Technology is a critical driver in optimizing crop planting structures (Balyan et al., 2024). However, some policies score low in terms of technical support, such as POL8, which received a score of only 0.6. Building on the successful experiences of the northeastern regions in grain production, as discussed in Section 5.1, it is recommended to increase investment in agricultural research and development, particularly in areas such as energy-efficient technologies, precision agriculture, and smart farming, to foster innovation in agricultural production methods. Policy support should also accelerate the dissemination of new agricultural technologies, including efficient water-saving irrigation systems, digital agriculture management platforms, and intelligent agricultural machinery, to raise the technological level of crop cultivation. Additionally, establishing a comprehensive agricultural technology promotion and service system is essential. This system should provide technical training and guidance to farmers and agricultural enterprises, enhancing their ability to adopt and apply new technologies, driving modernization, and promoting sustainable agricultural development—particularly in advancing crop rotation practices and improving grain quality.

5.3 Contributions and limitations

We have developed an evaluation system that encompasses various aspects such as policy objectives, implementing agencies, and incentives, providing a more comprehensive and systematic framework for assessing crop planting structure optimization policies. This holistic perspective moves beyond the traditional focus on singular policy effects, enabling a deeper understanding of the complexity and overall impact of these policies. In addition to emphasizing their overall effects, we conducted empirical analyses to explore the differential impacts of policies across regions and crop types. This cross-regional analytical approach highlights disparities and imbalances in policy implementation, offering scientific evidence for the formulation of more context-specific policies and demonstrating significant innovative value.

However, this study also has some limitations. While it systematically evaluates national-level policies, it provides relatively insufficient analysis of local policies. This limitation prevents the study from fully capturing the uniqueness and actual impact of local policies when assessing the differential effects of policy implementation across regions. Additionally, the study lacks an in-depth exploration of the long-term dynamic effects of policies. Future research should place greater emphasis on the implementation effects of local policies, particularly their specific outcomes in different regions. Moreover, a dynamic policy evaluation model should be developed to track and analyze the long-term effects of policies at various stages of development. This would help explore the need for policy adjustments and updates in response to changing economic, environmental, and social conditions, thereby offering more flexible and adaptive policy guidance.

6 Conclusion

Optimizing crop planting structure is an effective approach to addressing the conflict between resource scarcity and food production. The implementation of crop planting structure optimization policies is crucial for adjusting the agricultural supply structure and ensuring food security. This research systematically analyzed 171 policy documents related to crop planting structure optimization issued by the central government since 2003. Following the analytical framework of "policy formulation-policy tools-policy evaluation," we employed the PMC-Index model to construct a quantitative evaluation system for these policies. A comparative analysis was conducted on eight selected policy samples.

(1) From the perspective of policy text, the overall design of China's crop planting structure optimization policy is relatively sound. Among the eight policy samples, seven received acceptable grades, while one was rated as low. Although most policies demonstrate acceptable consistency, the study identifies several shortcomings in key areas, including the diversity of incentive mechanisms, the authority of policy-issuing agencies, the dynamic adjustment capability of policies, and interdepartmental collaboration.

(2) To enhance the overall effectiveness and implementation efficiency of policies, future efforts should focus on developing a more flexible and diverse incentive mechanism, strengthening interdepartmental collaboration and coordination, expanding policy coverage, enhancing the comprehensiveness of policy functions, and improving policy safeguard mechanisms. Additionally, it is recommended to further strengthen the agricultural technology promotion and service system to support the adoption of innovative farming practices.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

RS: Conceptualization, Data curation, Methodology, Software, Visualization, Writing – original draft. HS: Supervision, Validation, Writing – review & editing. GR: Supervision, Validation, Writing – review & editing. QW: Methodology, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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