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Developing an ESG Disclosure Quality Framework for the Agricultural Chemicals Industry: A GRI-Based Approach

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Abstract

Environmental, Social, and Governance (ESG) disclosure plays an increasingly important role in evaluating corporate sustainability performance. However, the agricultural chemicals industry faces unique environmental and social challenges, while existing ESG assessment frameworks remain largely generic and fail to capture industry-specific disclosure requirements. To address this gap, this study develops a multi-level ESG disclosure quality evaluation framework for the agricultural chemicals industry based on the GRI 2021 Standards, China's regulatory requirements, and sector-specific production characteristics. The framework was developed through targeted qualitative content analysis and text coding of ESG disclosures from ten listed agricultural chemical companies selected from the complete eligible population of 17 Chinese A-share agricultural chemicals enterprises that met the study's predefined inclusion criteria and had Huazheng ESG ratings. This process resulted in a hierarchical structure comprising three dimensions, 14 first-level indicators, 61 second-level indicators, and 350 third-level observation indicators, with particular emphasis on biodiversity conservation, farmer support, and corporate governance. The Analytic Hierarchy Process (AHP) was then applied to determine the weights of the first-level and second-level indicators through expert evaluation, while a three-point scoring system (0–2) was established for the third-level indicators to construct the industry-specific ESG disclosure quality evaluation model. The framework was subsequently evaluated using an independent sample of the remaining seven listed agricultural chemical companies. A benchmarking comparison with Huazheng ESG ratings showed broad alignment in overall patterns while also revealing important company-level differences and disclosure-quality gaps not readily captured by the general ESG ratings. Furthermore, multi-level ±20% weight perturbation analyses demonstrated the framework's stability, discriminative ability, industry suitability, and computational robustness. The proposed framework provides a practical and transparent tool for assessing ESG disclosure quality in the agricultural chemicals industry and offers a methodological foundation for developing sector-specific ESG disclosure evaluation frameworks in other high-impact industries.

Keywords: ESG disclosure quality; agricultural chemicals industry; GRI standards; targeted qualitative content analysis; analytical hierarchy process (AHP); China

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1. Introduction

In an increasingly competitive global business environment, sustainable development has become a top priority on the agendas of both enterprises and policymakers worldwide (Liu et al., 2024). As globalization deepens economic integration and competition dynamics, companies face growing pressure from stakeholders to balance economic performance with environmental protection and social responsibility. To address these global challenges, businesses have integrated sustainability practices into their daily operations. Specifically, numerous firms now incorporate environmental initiatives, social contributions, and enhanced governance structures into their strategic planning (Esposito De Falco et al., 2021). These efforts are typically reflected within the Environmental, Social, and Governance (ESG) framework, which aligns with internationally recognized standards for sustainability reporting and disclosure (Christofi et al., 2025; Eccles et al., 2020). Reflecting the growing importance of ESG in both research and practice, recent evidence indicates that ESG has become a rapidly expanding field of research, with increasing emphasis on industry-specific applications and the development of more refined evaluation frameworks (Yang & Kythreotis, 2026).

Effective ESG reports deliver significant tangible benefits to enterprises. Specifically, companies with superior ESG performance and higher-quality information disclosure typically exhibit greater customer loyalty (Abbasi et al., 2023), stronger brand credibility and corporate reputation (Koh et al., 2022), and better financial performance (Noja et al., 2024). Moreover, higher ESG scores are strongly associated with increased market capitalization (Christofi et al., 2024; Pasupuleti et al., 2024; Rahman et al., 2023). Thus, ESG reports hold strategic value in communicating sustainability practices, enhancing stakeholder trust, and driving long-term corporate growth.

Despite these advantages, the effectiveness of ESG reporting largely depends on the relevance and contextual applicability of the reporting framework employed. International sustainability reporting standards and frameworks, particularly the Global Reporting Initiative (GRI), provide standardized guidance for corporate sustainability disclosure, while ESG rating providers such as MSCI and Refinitiv assess companies using their own proprietary methodologies. However, neither general reporting frameworks nor broad ESG rating systems fully capture the distinctive operational characteristics, environmental risks, and regulatory requirements of China's agricultural chemicals industry (Leite de Almeida et al., 2025). Although the GRI Standards are designed for broad cross-industry application, their use in this sector remains relatively limited and insufficiently adapted to industry-specific sustainability issues, potentially preventing companies from fully realizing the strategic value of ESG reporting.

The lack of a quality assessment framework for ESG disclosures specific to particular industries limits the adequate reflection of industry-related environmental, social, and governance issues, thereby failing to fully meet the needs of regulatory authorities, investors, and enterprises seeking to enhance disclosure quality (L. Xu et al., 2024). This disconnect highlights the significant gap between global standardized ESG reporting frameworks and localized industry requirements and actual conditions. To address this issue, this study aims to develop an ESG disclosure quality assessment framework tailored to the characteristics of China's agricultural chemicals sector, addressing the shortcomings of existing international ESG reporting standards. To achieve this aim, the study pursues four interrelated objectives. First, it evaluates the feasibility of integrating the Global Reporting Initiative (GRI) Standards into a sector-specific ESG disclosure quality assessment framework. Second, it develops an ESG indicator system using the Analytic Hierarchy Process (Saaty, 1980) and targeted qualitative content analysis (Hsieh & Shannon, 2005) to ensure relevance, comparability, and practicality. Third, it examines differences in ESG disclosure

content and quality among agricultural chemical companies with varying ESG ratings. Finally, it evaluates the practical value of the proposed framework in supporting regulatory oversight, informing investment decisions, and promoting corporate self-improvement.

The comparison with Huazheng ESG ratings indicates broad alignment in overall patterns while also revealing important differences at the company level. Rather than seeking to reproduce Huazheng ratings, the proposed framework provides complementary, disclosure-specific information by identifying industry-specific reporting gaps that may not be captured by broader ESG rating systems. This distinction highlights the added value of sector-specific ESG disclosure assessment. This study contributes to the ESG disclosure literature in three important ways. First, it develops an industry-specific ESG disclosure quality assessment framework for China's agricultural chemicals industry, extending the application of the GRI Standards to a high-impact sector with unique sustainability challenges. Second, it proposes a transparent and replicable methodological approach that integrates targeted qualitative content analysis, the Analytic Hierarchy Process (AHP), and quantitative scoring to support the development of sector-specific ESG disclosure evaluation frameworks. Third, it demonstrates that industry-specific disclosure assessment complements existing ESG rating systems by providing a more context-sensitive evaluation of disclosure quality and identifying reporting differences that general ESG ratings may overlook.

2. Theoretical Framework

2.1. ESG Disclosure

Sustainable development theory, stakeholder theory, and legitimacy theory provide the theoretical foundation for the ESG disclosure evaluation system developed in this study for the agricultural chemicals industry. Together, these theories guide the selection of material issues, the development of indicator hierarchies, and the establishment of scoring criteria, creating a coherent framework that links disclosure content, evaluation rules, and practical application (Munro & Lammers, 1987).

From the perspective of sustainable development theory, universal baseline indicators and industry-specific indicators are distinguished by focusing on substantive sustainability risks rather than short-term financial performance. In the agricultural chemicals industry, this perspective emphasizes long-term environmental externalities, including hazardous chemical emissions and biodiversity loss, ensuring that the evaluation framework captures issues that are material to the sector rather than relying solely on generic ESG measures (Ruan et al., 2024). In addition, high-quality ESG disclosures help reduce information asymmetry in capital markets and strengthen firms' ability to manage operational and sustainability-related risks (Reber et al., 2022).

While sustainable development theory identifies the sustainability issues that should be addressed, stakeholder theory determines which of these issues are most important from the perspective of those affected by corporate activities. Freeman (2010) argued that corporate disclosures should respond to the information needs of stakeholders affected by business activities. In the agricultural chemicals industry, these stakeholders include regulators, farmers, upstream and downstream suppliers, and end consumers, each with distinct expectations regarding ESG information. These stakeholder perspectives inform the selection of industry-specific indicators and provide the basis for the expert weighting process using the Analytic Hierarchy Process (AHP). Accordingly, indicator importance is assessed across four key dimensions: operational risk, investor demand, regulatory compliance, and stakeholder accountability (Jessop et al., 2019). By contrast, universal reporting frameworks such as the GRI and ISSB standards do not fully address the sector-specific sustainability issues associated with agricultural chemicals (Santana Tovar et al., 2025).

Building on these principles, legitimacy theory explains how the quality of ESG disclosures should be evaluated. Suchman (1995) argued that detailed, transparent, and measurable sustainability disclosures enable organizations to gain and maintain social legitimacy. However, legitimacy depends not only on the disclosure of sustainability information but also on the organizational capacity to translate that information into effective governance practices. Recent evidence from risk-oriented collaborative governance suggests that the existence of formal governance structures and risk documentation alone is insufficient unless risk information is institutionalized through routine coordination forums, operational rules, transparent decision-making processes, and participatory accountability mechanisms (Purnama et al., 2026). Although these findings are drawn from a disaster risk governance context, they reinforce the broader governance principle that credible ESG disclosure should reflect not only the reporting of environmental risks but also the institutional capacity to translate disclosed information into preventive and coordinated action. This distinction between documenting risks and institutionalizing their management further supports the inclusion of governance-related indicators addressing environmental risk identification, emergency response, stakeholder communication, external governance collaboration, and transparency within the proposed ESG disclosure quality evaluation framework.

Given the significant environmental and public safety concerns associated with the agricultural chemicals industry, the proposed framework adopts a three-point scoring system (0–2), assigning higher scores to detailed quantitative disclosures and to the transparent reporting of industry-specific risks, while more generic disclosures receive lower scores. This approach reflects the view that legitimacy is strengthened not only through the disclosure of positive achievements but also through transparent reporting of material sustainability risks and challenges (Shen et al., 2023; Seletska, 2024). This principle also underpins the need for an industry-specific ESG disclosure quality assessment framework. However, credible ESG disclosure depends not only on the quality of the information reported but also on the governance mechanisms and organizational behaviors that support transparent and accountable reporting practices. Formal governance structures alone are unlikely to produce credible ESG disclosure unless they are reinforced by behavioral integrity and organizational norms that encourage employees to act responsibly beyond minimum compliance requirements. Research synthesizing integrity and organizational citizenship behavior highlights the importance of these behavioral mechanisms in translating governance principles into consistent organizational practice (Saputra et al., 2026). Although this evidence is drawn from the public management literature, it reinforces the broader governance principle that credible ESG disclosure depends not only on formal governance arrangements but also on organizational behaviors that support ethical conduct, accountability, and responsible decision-making.

Taken together, these three theoretical perspectives provide the conceptual foundation for developing an industry-specific ESG disclosure evaluation framework. Their relevance is particularly evident in China's agricultural chemicals industry, which is one of the world's largest producers and consumers of agricultural chemicals, making the sector strategically important for food security and green international trade competitiveness (Y. Xu & Chen, 2025). At the same time, the industry faces distinctive environmental and social challenges, including hazardous emissions, farmland degradation, and the protection of farmers' rights. Nevertheless, many Chinese agricultural chemical companies continue to rely on generic ESG reporting templates, resulting in limited disclosure of industry-specific sustainability issues and relatively superficial reporting of environmental and social responsibilities (Zhou & Nian, 2024). By incorporating the principles of sustainable development, stakeholder, and legitimacy theories, the proposed sector-specific disclosure evaluation framework

provides a more comprehensive assessment of ESG disclosure quality, enabling companies to identify reporting gaps, improve transparency, reduce financing constraints, and better respond to green trade requirements (Nurlatifah et al., 2025).

2.2. Global Reporting Initiative (GRI) Standards and China

In terms of international standards, since the Global Reporting Initiative (GRI) first released the draft of the Guidelines for Sustainability Reporting in 1999, its framework has undergone multiple revisions. The framework has progressively evolved from a three-dimensional system covering economic, environmental, and social dimensions to the 2021 version of the GRI Universal Standards and the 2022 version of GRI 13: Agriculture, Aquaculture and Fishing Sectors, thereby establishing a global information disclosure framework that covers cross-sectoral and industry-specific issues. Concurrently, organizations such as SASB, ISSB, and TNFD have successively introduced standards addressing investor rights and nature-related topics. These standards are progressively refining GRI's methodology for materiality identification and indicator definition, laying the technical foundation for cross-border comparability analysis and the refinement of industry-specific standards. Accordingly, the GRI Standards provide the international benchmark upon which this study builds its industry-specific ESG disclosure quality evaluation framework.

China has gradually improved its regulatory framework for environmental information disclosure. Since the Ministry of Ecology and Environment issued the Guidelines for Environmental Information Disclosure by Listed Companies (Draft for Comments) in 2010 (Ministry of Ecology and Environment [MEE], 2010), the country has successively introduced several institutional documents, including the Environmental Protection Law (Revised Version-2015) (Standing Committee of the National People's Congress [SCNPC], 2015), the Measures for the Management of Environmental Information Disclosure by Key Polluting Units (MEE, 2019), the Interim Measures for Carbon Emission Trading Management (2020) (National Development and Reform Commission [NDRC], 2020), and the Measures for the Legal Public Disclosure of Corporate Environmental Information (MEE, 2021). These regulations systematically strengthen enterprises' obligations to disclose environmental information and enhance the accuracy requirements for disclosed content. Together, these regulatory developments establish the national institutional context within which ESG disclosures are prepared and evaluated in China.

In 2024, the China Securities Regulatory Commission issued the Sustainability Reporting Standards (Trial) and the Draft Enterprise ESG Disclosure Standards for 2024, establishing for the first time a nationally unified ESG disclosure framework and a core indicator system for quality assessment. These regulations not only specify information disclosure requirements for agricultural chemicals enterprises in environmental and climate governance, pollutant emission permits, and resource management but also provide a policy framework for identifying key disclosure dimensions. Building on the theoretical foundations discussed in the previous section, this study develops an industry-specific ESG disclosure quality evaluation framework by integrating the GRI Standards, China's regulatory requirements (summarized in Supplementary File S1), relevant academic research, and the sustainability characteristics of the agricultural chemicals industry. This integrated approach ensures that the proposed framework remains internationally comparable while reflecting the regulatory environment and sustainability priorities of China's agricultural chemicals sector, resulting in a scientifically rigorous, policy-compliant, and industry-relevant assessment system.

3. Materials and Methods

This study employs the Analytic Hierarchy Process (AHP) proposed by Saaty (1980) to develop an evaluation framework for the agricultural chemicals industry. Existing research has extensively applied AHP in various domains, including supply chain performance assessment (Saleheen et al., 2018), agricultural supply chain decision analysis (Toloi et al., 2021), and risk factor evaluation (Pecchia et al., 2011). Rebstock and Kaula (1996) demonstrated AHP's effectiveness through case studies; further, Helm et al. (2004) noted that AHP exhibits smaller estimation errors compared to other methods.

This section outlines the methodology for developing an ESG indicator system through a four-step process, covering sample selection, initial model construction, output model development, and textual validation of the structural model (Section 3.1), while also detailing the approach to designing indicator weights and the computational workflow based on AHP analysis (Section 3.2).

3.1. Development and Validation of the ESG Indicator System

3.1.1. Sample Selection

The sample selection aims to identify the study subjects and ensure that the samples meet analytical requirements in terms of industry representativeness, data availability, and rating comparability, thereby laying a solid foundation for establishing an ESG information disclosure quality assessment system for the agricultural chemicals industry based on GRI standards.

Agricultural chemical products specifically refer to pesticides and chemical fertilizers, with chemical fertilizers including nitrogen fertilizers, phosphorus fertilizers, potassium fertilizers, compound fertilizers, and organic fertilizers. Based on the Shenyin Wanguo Industry Classification 2021 Revised Edition, this study categorises the agricultural chemical products industry into five subsectors: pesticides, nitrogen fertilizers, phosphorus fertilizers and phosphorus chemicals, potassium fertilizers, and compound fertilizers. These sectors are uniformly classified under C26 (Chemical Raw Materials and Chemical Products Manufacturing) in the national standard GB/T 4754-2017 classification system (AQSIQ & SAC, 2017). In 2024, there were 58 enterprises meeting the definition of the agricultural chemical products industry, increasing to 59 in 2025. Among these companies, only 17 published ESG sustainability reports and maintained a Huazheng Overall ESG Rating of B or above in both 2024 and 2025. Consequently, these 17 enterprises represent the complete eligible population satisfying the study's predefined inclusion criteria, rather than a sample drawn from a larger pool of qualifying companies (see Table 1). During the sample screening process, the following criteria were adopted: (1) the enterprise must have submitted complete ESG reports, sustainability reports or social responsibility reports for both 2024 and 2025; and (2) the enterprise must have maintained a Huazheng Overall ESG Rating of B or above in both years. Enterprises rated CCC or below generally exhibited substantial limitations in the availability and completeness of ESG disclosure data, making it impossible to conduct comprehensive qualitative content coding and indicator development. Therefore, they were excluded from the study. The adoption of a consecutive two-year rating criterion helps avoid sample bias caused by temporary improvements in annual disclosures, while setting level B as the minimum inclusion threshold allows coverage of enterprises spanning a broad spectrum of disclosure quality, from relatively weak to high-quality disclosures, thereby providing a solid basis for distinguishing different levels of ESG disclosure quality.

The 17 listed agricultural chemicals enterprises on the A-share market span different Huazheng ESG rating levels and constitute the complete eligible population identified for this study. Addressing both the need for indicator development and the requirement

for independent model validation, these 17 enterprises were divided into two mutually exclusive independent samples.

Table 1. Sample of listed agricultural chemical companies.

No.	Company	Stock Code	Industry	2024 Report	2024 Rating	2025 Report	2025 Rating
1	Qinghai Salt Lake Industrial Co., Ltd.	000792.SZ	Potassic fertilizer	Social Responsibility Report	A	ESG Report	A
2	Zangge Mining Co., Ltd.	000408.SZ	Potassic fertilizer	Sustainable Development Report	BBB	Sustainable Development Report	A
3	Limin Holding Group Co., Ltd.	002734.SZ	Pesticide	ESG Report	A	ESG Report	A
4	Andoomai Co., Ltd.	000553.SZ	Pesticide	Social Responsibility Report	A	ESG Report	BBB
5	Sichuan Meifeng Chemical Co., Ltd.	000731.SZ	Nitrogenous fertilizer	ESG Report	BBB	ESG Report	AA
6	Zhejiang Xin'an Chemical Group Co., Ltd.	600596.SH	Pesticide	ESG Report	BBB	ESG Report	A
7	Jaben Chemical Co., Ltd.	300261.SZ	Pesticide	ESG Report	BB	ESG Report	BBB
8	Yunnan Yuntianhua Co., Ltd.	600096.SH	Phosphorus fertilizers and phosphorus chemicals	ESG Report	BB	ESG Report	A
9	Shandong Hualu Hengsheng Chemical Co., Ltd.	600426.SH	Nitrogenous fertilizer	ESG Report	BBB	ESG Report	BBB
10	Jiangsu Yangnong Chemical Co., Ltd.	600486.SH	Pesticide	ESG Report	BBB	ESG Report	A
11	Hubei Yihua Chemical Co., Ltd.	000422.SZ	Phosphorus fertilizers and phosphorus chemicals	Sustainable Development Report	B	Sustainable Development Report	BBB
12	Xinyangfeng Agricultural Technology Co., Ltd.	000902.SZ	Compound fertilizer	Social Responsibility Report	B	Social Responsibility Report	B
13	Lianhua Technology Co., Ltd.	002250.SZ	Pesticide	Social Responsibility Report	B	Social Responsibility Report	B
14	Jinzhengda Ecological Engineering Group Co., Ltd.	002470.SZ	Compound fertilizer	ESG Report	BB	ESG Report	B
15	Hubei Xingfa Chemical Group Co., Ltd.	600141.SH	Phosphorus fertilizers and phosphorus chemicals	ESG Report	B	ESG Report	AA

Table 1. *Cont.*

No.	Company	Stock Code	Industry	2024 Report	2024 Rating	2025 Report	2025 Rating
16	Jiangxi Guangxin New Materials Co., Ltd.	603599.SH	Pesticide	Social Responsibility Report	B	Social Responsibility Report	B
17	Shaanxi Meibang Pharmaceutical Group Co., Ltd.	605033.SH	Pesticide	Social Responsibility Report	B	Social Responsibility Report	B

Note. Company names and stock codes were obtained from LSEG. ESG disclosure reports were collected from the official websites of the listed companies and the China Securities Information Network. Huazheng ESG ratings were obtained from the official Huazheng Index database. Companies 1–10 constitute the development sample, while Companies 11–17 constitute the validation sample. Membership in the development sample required a Huazheng Overall ESG Rating of BB or above in both 2024 and 2025; the validation sample comprises the remaining eligible companies that did not meet this two-year threshold.

The first sample comprised 10 enterprises that maintained a Huazheng Overall ESG Rating of BB or above in both 2024 and 2025. This two-year threshold was used to identify companies with a consistently stronger rating profile and sufficiently comprehensive ESG disclosures to support qualitative content analysis, the identification of industry-specific indicators, and framework development. The reports of these companies enabled detailed exploration of substantive industry issues and supported the development of the GRI-aligned framework, targeted qualitative content coding, and subsequent AHP-based weighting.

The second sample comprised the remaining seven eligible enterprises that did not maintain a Huazheng Overall ESG Rating of BB or above in both 2024 and 2025 and was reserved exclusively for independent validation. Each of these companies received a B rating in at least one of the two years, resulting in a validation sample with a lower and more variable Huazheng rating profile over the two-year selection period than the development sample. Their ESG reports also exhibited substantial variation in the breadth and detail of disclosure, providing an appropriate basis for assessing whether the proposed framework could discriminate among different levels of disclosure quality. Importantly, the seven companies were assigned to the validation sample on the basis of the predefined two-year Huazheng rating criterion, rather than on the disclosure-quality classifications subsequently generated by the proposed framework. To preserve the independence of the validation process, their reports were not used at any stage of indicator screening or framework development. Instead, they were used exclusively for independent holdout-sample validation, case analysis, and multi-level $\pm 20\%$ weight perturbation robustness tests.

3.1.2. Initial Model Development

The initial model development phase aims to establish a preliminary ESG disclosure framework for the agricultural chemicals industry, which is subsequently subjected to independent holdout-sample validation. This study adopts a top-down approach to systematically review the relevant disclosure requirements outlined in the "GRI Universal Standards 2021" and the "GRI 13: Agriculture, Aquaculture and Fishing Sectors 2022" and integrates these requirements with policy documents such as the "14th Five-Year Plan for Green Development of Agriculture in China," the "Pesticide Management Regulations," and the "Compilation of Policies on Carbon Peaking and Carbon Neutrality."

At the systemic-level design stage, this framework establishes the three ESG dimensions, Environmental (E), Social (S), and Governance (G), as the criterion layer. Beneath the criterion layer, the framework defines 14 first-level indicators, 61 second-level indicators, and 350 third-level observation indicators. All second-level indicators are aligned with the corresponding original clauses of the GRI Standards, while incorporating domestic

regulatory policies for the agricultural chemicals industry to provide localized adaptation explanations and indicator optimization rationale. This comprehensive evaluation framework not only benchmarks against international sustainable disclosure standards but also fully aligns with the production and operational characteristics of China's agricultural chemical industry and its specific regulatory requirements. All third-level observation indicators are categorized into three types, qualitative, quantitative, and mixed, together with standardized definitions, accounting units, and supporting documentation requirements corresponding to the three-point scoring system. The complete list of indicators is detailed in Supplementary File S2.

3.1.3. Construct the Outcome Model

Following the establishment of the initial indicator framework, this study analyzed 20 ESG reports from 10 agricultural chemical companies in the dataset covering the 2024–2025 period. A three-tiered indicator list was ultimately adopted, with each report's text meticulously coded sentence by sentence to ensure that every statement corresponded to a specific framework indicator, thereby enabling systematic coding and textual validation (see Table 2).

3.1.4. Text Validation for Structural Models

This study employed the targeted qualitative content analysis method to conduct structured text coding (Hsieh & Shannon, 2005), using the GRI Standards and domestic agricultural chemicals industry regulatory policies as the predefined analytical framework. The coding process was iterated based on samples selected from ten indicators, with textual consistency checks verifying the stability and industry suitability of the indicator framework. Text analysis results demonstrated that the frequently reported themes in corporate reports align closely with the essence of the indicator system developed in this study. Synonymous expressions, such as "circular economy" corresponding to "saltwater recycling system construction," were uniformly categorized and merged to ensure comprehensive coverage and reliable measurement differentiation within the system.

The text encoding results indicate that even agricultural chemical companies with higher ratings still exhibit deficiencies in disclosure regarding specialized environmental aspects and product safety issues, with widespread gaps in specific components such as pesticide toxicity test data, wetland ecological impact assessments, and emergency response measures for hazardous chemical leaks. To enhance industry-specific monitoring indicators, this study draws on publicly available sustainability reports from Bayer Crop Science and Syngenta as external Supplementary Materials, while incorporating additional detailed evaluation metrics derived from domestic regulations, including the Pesticide Administration Regulations and China's High-Quality Development Action Plan for the Pesticide Industry (2022–2025). Without altering the fundamental framework, these additions enrich specialized industry observation dimensions, improve the rigor, completeness, and industry applicability of the assessment system, and provide practical tools for evaluating disclosure quality and optimizing corporate sustainability reporting.

Table 2. Examples of Industry-Specific ESG Disclosure Indicators Extracted from Corporate Reports.

Excerpt from the Original Corporate Report	Level 3 Indicator	Second-Level Indicator	GRI-Compatible Level 1 Indicator	ESG Dimension	Standardised Semantic Mapping
Quantification of investment returns from energy-saving technological upgrades and synergistic control mechanisms	Quantification of investment returns from energy-saving technological upgrades and synergistic control mechanisms	Energy Management and Energy Efficiency Improvement	Climate Change and Energy Management	Environment	Energy-saving technological upgrades, energy-efficiency improvements, and energy-consumption control
Quantitative control of the total amount and concentration of pollutants discharged into water bodies	Quantitative control of the total amount and concentration of pollutants discharged into water bodies	Water Pollution Prevention and Control	Water Resource Management and Water Conservation Measures	Environment	Wastewater discharge, pollutant control, and water-quality improvement
Optimisation of a diversified talent structure and establishment of a system for developing female talent	Optimisation of a diversified talent structure and establishment of a system for developing female talent	Employee Development and Capacity Building	Employee Development and Occupational Health	Social	Talent structure, women's development, and employee growth
Quantitative management of offline agricultural technology training for farmers	Quantitative management of offline agricultural technology training for farmers	Technical and Knowledge Support	Rural Development and Farmer Empowerment Support	Social	agricultural technology training, farmer support, and technology promotion
Regular updates and continuous improvement of the compliance management system	Regular updates and continuous improvement of the compliance management system	Enterprise Legal Compliance Management	Compliance and Risk Management Mechanisms	Governance	Compliance management, system improvement, and internal control
Protection of the rights and interests of small and medium-sized investors and development of voting mechanisms	Protection of the rights and interests of small and medium-sized investors and development of voting mechanisms	Stakeholder Communication	Information Disclosure and Stakeholder Management Mechanisms	Governance	Investor protection, shareholder rights, and stakeholder communication

3.2. Methodology

This study employs the Analytic Hierarchy Process (AHP) proposed by Thomas L. Saaty in the 1970s (Saaty, 1980, 1994) to determine indicator weights and construct a standard layer, namely the core ESG dimensions. The AHP method decomposes complex decision-making problems into an objective layer, a standard layer, and an indicator layer, enabling comprehensive weight allocation that integrates both qualitative and quantitative elements.

AHP is designed to analyze problems across multiple levels. The highest level focuses on the core issue to be addressed, while intermediate levels examine the various factors influencing decision-making. Specifically, the system comprises a first-level indicator layer containing 14 items corresponding to the adjusted first-level indicators in the GRI framework, a second-level indicator layer containing 61 items aligned with GRI or industry-specific second-level indicators, and a third-level indicator layer containing 350 empirical observation indicators quantified using a three-point scoring system.

3.2.1. Paired Comparison Matrix

The Analytic Hierarchy Process (AHP) was employed to conduct pairwise comparisons among the evaluation criteria using Saaty's 1–9 absolute scale (Table 3). Using "ESG Information Disclosure Quality" as the target layer, a five-level hierarchy was established comprising the target layer, the ESG criterion layer, the first-level indicator layer, the second-level indicator layer, and the third-level indicator layer. Because the third-level indicators serve solely as observation and scoring items, no pairwise comparison matrices were constructed and no separate weights were assigned to this level. Pairwise comparison judgment matrices were progressively constructed for all higher hierarchical levels. The pairwise comparison matrix $A^{(k)}$ is defined as follows:

$$A^{(k)} = \begin{bmatrix} 1 & a_{12}^{(k)} & \cdots & a_{1n}^{(k)} \\ \frac{1}{a_{12}^{(k)}} & 1 & \cdots & a_{2n}^{(k)} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}^{(k)}} & \frac{1}{a_{2n}^{(k)}} & \cdots & 1 \end{bmatrix} \quad (1)$$

Table 3. Relative scales for paired comparison.

Scale	Definition	Description
1	Equally important	The two factors are equally important.
3	Moderate importance	One factor is moderately more important than the other.
5	Strong importance	One factor is strongly more important than the other.
7	Very strong importance	One factor is very strongly more important than the other.
9	Extreme importance	One factor is extremely more important than the other.
2, 4, 6, 8	Intermediate values	Used when a compromise between two adjacent judgments is required.
1, 1/2, . . ., 1/9	Reciprocal values	Used when the comparison is made in the opposite direction.

Note: For details, please refer to Saaty (1980).

Here, $i, j = 1, 2, \ldots, n$, where n denotes the number of comparison indicators at the corresponding hierarchical level. The element $a_{ij}^{(k)}$ represents expert k's assessment of the relative importance of indicator i compared with indicator j, where $k = 1, \ldots, m$, and m denotes the total number of valid experts. The matrix is a positive reciprocal matrix whose diagonal elements are equal to 1 and which satisfies $a_{ij}^{(k)} = 1/a_{ji}^{(k)}$.

The Saaty 1–9 absolute scale (Saaty, 1980) and its reciprocal values were employed to conduct the pairwise comparisons (Table 3). The complete AHP expert questionnaire

used for these comparisons, including the criterion-, first-level-, and second-level indicator structures, is provided in Supplementary File S3 of the Supplementary Materials. The resulting matrices capture the relative importance of indicators within each hierarchical level and provide the basis for deriving the corresponding local priority vectors.

3.2.2. Expert Sample

A total of 30 questionnaires were distributed in this study, with 26 valid responses collected, yielding an effective response rate of approximately 86.67%. Experts were purposively selected to form a multidisciplinary panel with relevant academic, industry, and policy-related expertise for the AHP evaluation. The selection process aims to ensure appropriate professional and sectoral representation across the agricultural chemicals industry and related sustainability fields. The experts were specifically categorized into three groups:

(1) Ten associate professors and researchers from universities and research institutions with long-term experience in ESG, sustainable development, environmental management, and corporate social responsibility;
(2) Nine senior executives from the agricultural and related chemical industries, as well as heads of environmental health and safety departments with experience in ESG report preparation or management; and
(3) Seven professionals from policy-making bodies, standard-setting organizations, and third-party evaluation agencies.

During the scoring process, third-level indicators served as reference criteria for evaluating second-level indicators, ensuring that experts assessed the indicators based on consistent and comprehensive criteria and thereby enhancing the accuracy and consistency of the evaluation outcomes. This study strictly adhered to ethical principles, including anonymity and confidentiality, while guaranteeing participants' right to withdraw at any time. All participation was voluntary, with written informed consent obtained from all participants before the survey began. Throughout the research design, implementation, and reporting phases, relevant ethical standards were rigorously observed in accordance with established research ethics guidelines. Participants' rights, privacy, and anonymity were fully protected.

3.2.3. Aggregation of Individual Judgments, Calculation of Weights, and Determination of the Consistency Ratio

The 26 experts comprising the multidisciplinary panel independently constructed pairwise comparison matrices at the relevant hierarchical levels. To prevent inconsistent individual judgments from being concealed during aggregation, consistency tests were first conducted separately for each expert's matrix. Only questionnaires in which all pairwise comparison matrices achieved a consistency ratio below 0.10 were included in the aggregation process.

For the expert judgment matrices that passed the consistency test, the group pairwise comparison matrix was constructed using the geometric mean method. For each pair of indicators (i, j), the aggregated judgment was calculated as follows:

$$\bar{a}_{ij} = \left(\prod_{k=1}^{m} a_{ij}^{(k)} \right)^{1/m} \quad (2)$$

where $m = 26$ denotes the total number of valid expert responses, and $a_{ij}^{(k)}$ represents the relative importance assigned by expert k to indicator i compared with indicator j. The geometric mean method was used because it preserves the reciprocal structure of the

individual pairwise comparison matrices. Accordingly, the aggregated matrix satisfies the positive reciprocal property:

$$\overline{a}_{ij} = \frac{1}{\overline{a}_{ji}}$$

or, equivalently,

$$\overline{a}_{ij}\overline{a}_{ji} = 1.$$

After constructing the aggregated $n \times n$ matrix $\overline{A} = (\overline{a}_{ij})$, each element was normalised by the sum of its corresponding column:

$$\widetilde{a}_{ij} = \frac{\overline{a}_{ij}}{\sum_{p=1}^{n} \overline{a}_{pj}} \quad (3)$$

where $i, j = 1, 2, \ldots, n$. The denominator represents the sum of all elements in column j.

The arithmetic mean of each row of the normalized matrix was then calculated to obtain the preliminary weight for indicator i:

$$\overline{w}_i = \frac{1}{n}\sum_{j=1}^{n} \widetilde{a}_{ij} \quad (4)$$

where $\widetilde{a}_{ij}$ denotes the column-normalised matrix element obtained from Formula (3), and n represents the number of indicators at the corresponding hierarchical level. The preliminary weights were subsequently normalised to obtain the final weight vector:

$$w_i = \frac{\overline{w}_i}{\sum_{p=1}^{n} \overline{w}_p} \quad (5)$$

such that:

$$\sum_{i=1}^{n} w_i = 1.$$

The largest eigenvalue of the aggregated pairwise comparison matrix was estimated as follows:

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(\overline{A}w)_i}{w_i} \quad (6)$$

where n denotes the order of the matrix, w is the final weight vector, and $(\overline{A}w)_i$ represents the i-th component of the vector obtained by multiplying the aggregated matrix $\overline{A}$ by w.

The consistency index was calculated as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (7)$$

The consistency ratio was then calculated as:

$$CR = \frac{CI}{RI} \quad (8)$$

where λ_{max} is the largest eigenvalue of the aggregated matrix, CI is the consistency index, and RI is Saaty's random consistency index, as presented in Table 4. If $CR < 0.10$, the aggregated pairwise comparisons are considered sufficiently consistent, and the resulting weights are regarded as acceptable.

Table 4. Random Consistency Index.

N	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Note: For details, please refer to Saaty (1980).

4. Results

4.1. Pairwise Comparison of ESG Scores with Weight Allocation Results

The expert questionnaire-based weighting methodology integrates two theoretical frameworks, stakeholder demands and industry legitimacy pressures, and incorporates four substantive criteria, operational risk, investor expectations, regulatory compliance, and stakeholder accountability, as the basis for assigning priority scores to the indicators. Table 5 presents the weights assigned to each ESG indicator (Environmental, Social, and Governance). The research findings indicate that, at this level, the environmental dimension carries the highest weight (wE = 0.4211), suggesting that environmental issues are widely regarded as having a more significant impact on the overall assessment of ESG information disclosure quality within the agricultural chemicals industry. This is followed by the governance dimension (wG = 0.3743) and the social dimension (wS = 0.2045), reflecting the industry's strong emphasis on compliance management, strategic execution, and information quality. Although the weight assigned to the social dimension is relatively low, it still occupies an important position within the overall framework, highlighting the irreplaceable role of social responsibility in the sustainable development of the industry.

Table 5. Pairwise Comparison Matrix of ESG Indicators at the Criterion Level.

	Environmental (E)	**Social (S)**	**Governance (G)**	**Local Weight w_i**
Environmental (E)	1.0000	2.2223	1.0438	0.4211
Social (S)	0.4500	1.0000	0.5882	0.2045
Governance (G)	0.9580	1.7001	1.0000	0.3743

Note: This matrix was derived from the geometric mean of 26 expert judgment matrices that passed independent consistency testing. Matrix element a_{ij} represents the importance of indicator i relative to indicator j, assigned using the Saaty 1 to 9 scale and its reciprocal values. The table illustrates only the calculation process for criterion level weights. Therefore, all weights shown are hierarchical local weights.

Table 6 presents the overall weight distribution of the ESG disclosure quality assessment framework developed in this study based on the GRI 2021 Standards. The results show the weight allocation for each first-level and second-level indicator across the three dimensions, Environmental, Social, and Governance. Within the environmental dimension, Climate Change and Energy Management has the highest weight (0.2364). Within the social dimension, Supply Chain ESG Management carries the highest weight (0.3311). Within the governance dimension, Corporate Governance Structure and Oversight Mechanisms has the highest weight (0.3176). Among the second-level indicators, Product Risk and Safety Management receives the highest local weight (0.6553).

To verify the reliability of the weight calculations at each hierarchical level, this study calculated the maximum eigenvalue (λmax), the consistency index (CI), and the consistency ratio (CR) for the judgment matrices independently constructed for the criterion layer, all first-level indicators, and all second-level indicators. The complete results are presented in Table 7.

Table 6. Weight Distribution Results of the ESG Indicator System for the Agricultural Chemicals Industry Based on GRI Standards.

ESG Dimension	Criterion Weight	First-Level Indicator	First-Level Indicator Weight	Second-Level Indicator	Second-Level Indicator Weight
Environmental (E)	0.4211	Climate Change and Energy Management	0.2364	Clean Energy Use	0.1276
				Greenhouse Gas Emissions	0.3037
				Carbon Footprint Assessment and Accounting	0.2363
				Green Logistics and Carbon Reduction	0.0802
				Energy Management and Energy Efficiency Improvement	0.2522
		Water Resource Management and Water Conservation Measures	0.1344	Drought Response Measures	0.1106
				Water Reuse	0.2615
				Water Pollution Prevention and Control	0.1952
				Water Resource Conservation Improvements	0.1171
				Water Resource Risk Assessment and Performance Evaluation	0.1539
				Water Consumption	0.1617
		Pollution Prevention and Control; Waste Management	0.2059	Treatment of Wastewater, Waste Gas, and Solid Waste	0.2161
				Agricultural Chemical Residue Control	0.1610
				Waste Disposal	0.2144
				Hazardous Substance Storage Management	0.1135
				Upgrading and Retrofitting of Environmental Protection Facilities	0.2147
				Environmental Remediation and Governance	0.0803
		Environmental Risk Identification and Emergency Response	0.1963	Pollution Incident Reporting System	0.2996
				Leakage Incident Emergency Response	0.4122
				Emergency Response Plan for Sudden Environmental Incidents	0.2881
		Ecological Protection and Biodiversity Management	0.0634	Assessment of the Ecological Impacts of agricultural chemicals	0.3387
				Wetland Impact Assessment	0.1086
				Biodiversity Monitoring	0.3249
				Non-target Biological Protection	0.2423
		Green Product and Raw Material Management	0.1636	Product Label: Environmental Friendliness	0.3756
				Toxicological Testing of agricultural chemicals	0.4191
				Research and Development of Green Agricultural Inputs and Ecological Products	0.2052

Table 6. *Cont.*

ESG Dimension	Criterion Weight	First-Level Indicator	First-Level Indicator Weight	Second-Level Indicator	Second-Level Indicator Weight
Social (S)	0.2045	Supply Chain ESG Management	0.3311	Comprehensive ESG Management Across the Entire Supply Chain Process	0.5493
				Transportation and Compliance Management of Hazardous Chemicals	0.4507
		Rural Development and Farmer Empowerment Support	0.1805	Rural Public Welfare Assistance and Community Development	0.2169
				Technical and Knowledge Support	0.4108
		Employee Development and Occupational Health	0.2679	Economic Integration and Localization Strategies	0.3723
				Employee Development and Capacity Building	0.2509
				Occupational Safety and Control of Occupational Diseases	0.2877
				Employee Cultural Activities and Motivation	0.0558
				Employee Well-being and Health Care	0.0980
				Employee Structure and Diversity Management	0.1316
				Employee Compensation Management	0.1760
		Customer Responsibility and Product Safety	0.2204	Product Risk and Safety Management	0.6553
				Customer Service and Rights Protection	0.3447
Governance (G)	0.3743	ESG Information Disclosure and Stakeholder Communication	0.2098	ESG Information Disclosure Timeline	0.3543
				ESG Information Quality	0.4204
				Stakeholder Communication	0.2433
		Corporate Governance Structure and Oversight Mechanisms	0.3176	Corporate Governance Structure and Responsibilities	0.3795
				Business Ethics and Anti-Fraud Measures	0.3129
				External Governance Collaboration	0.1363
		Compliance and Risk Management Mechanisms	0.2836	Industry Governance and Joint Standard Development	0.1713
				ESG Annual Compliance Audit	0.2114
				ESG Risk Identification and Mitigation	0.1580
				Enterprise Legal Compliance Management	0.2419
				Compliance Management for Hazardous Chemicals	0.1014
				Environmental Law Compliance Review	0.2139
				Carbon Market Compliance and Performance	0.0733

Table 6. *Cont.*

ESG Dimension	Criterion Weight	First-Level Indicator	First-Level Indicator Weight	Second-Level Indicator	Second-Level Indicator Weight
		Digital Transformation and Sustainable Operations Management Systems	0.1890	ESG Data Collection and Tracking Platform Management	0.1806
				Promotion and Application of ESG-related Technological Achievements	0.0814
				Digital Supply Chain Procurement Control	0.2007
				Application Management of Digital Financial Settlement Tools	0.0869
				Intelligent Manufacturing and Digital Integration	0.1353
				Intelligent Operations Integrating Industrialisation and Informatization	0.1495
				Strategic Management of Green Digital Technology	0.1103
				Digital Control of Sales Channel Management	0.0552

Note: This table presents the hierarchical weight distribution across the criterion, first-level indicator, and second-level indicator layers of the proposed ESG disclosure quality assessment framework. For definitions of all indicators, scoring criteria, policy and GRI sources, indicator types, hierarchical mappings, and the treatment of non-applicable indicators across the 350 third-level observation indicators, refer to Supplementary File S2, "Dictionary of ESG Standardized Indicators for the agricultural chemicals Industry." The supplementary dictionary is structured to provide the information required to apply the coding instrument consistently and reproduce the scoring procedure.

Table 7. Consistency Test Results for Judgment Matrices at All Hierarchical Levels.

Hierarchy Level	Pairwise Comparison Matrix	Matrix Order (*n*)	λmax	CI	CR
Criterion Layer	ESG Criteria (E, S, G)	3	3.006	0.0030	0.0052
Environmental (E)	First-level indicators	6	6.038	0.0076	0.0061
	Climate Change and Energy Management	5	5.041	0.0103	0.0091
	Water Resource Management and Water Conservation Measures	6	6.133	0.0266	0.0215
	Pollution Prevention and Waste Management	6	6.054	0.0108	0.0087
	Environmental Risk Identification and Emergency Response	3	3.004	0.0020	0.0034
	Ecological Protection and Biodiversity Management	4	4.004	0.0013	0.0015
	Green Product and Raw Material Management	3	3.003	0.0015	0.0026
Social (S)	First-level indicators	4	4.023	0.0077	0.0085
	Supply Chain ESG Management	2	2.000	0.0000	0.0000
	Rural Development and Farmer Empowerment Support	3	3.004	0.0020	0.0034
	Employee Development and Occupational Health	6	6.076	0.0152	0.0123
	Customer Responsibility and Product Safety	2	2.000	0.0000	0.0000
Governance (G)	First-level indicators	4	4.031	0.0103	0.0114
	ESG Information Disclosure and Stakeholder Communication	3	3.004	0.0020	0.0034
	Corporate Governance Structure and Oversight Mechanisms	4	4.034	0.0113	0.0126
	Compliance and Risk Management Mechanisms	6	6.127	0.0254	0.0205
	Digital Transformation and Sustainable Operations Management Systems	8	8.219	0.0313	0.0222

Notes: λ_{max} = maximum eigenvalue of the pairwise comparison matrix; CI = Consistency Index; CR = Consistency Ratio; *n* = number of compared elements (matrix order) in the corresponding pairwise comparison matrix. The criterion layer matrix compares the three ESG criteria (Environmental, Social, and Governance) with respect to the overall objective of the ESG disclosure quality evaluation framework, whereas the remaining matrices compare the indicators within each corresponding hierarchical level. According to Saaty (1980), a CR value below 0.10 indicates acceptable consistency of expert judgments. All pairwise comparison matrices satisfied this criterion.

As shown in Table 7, the consistency ratio (CR) for all hierarchical matrices is well below 0.10, satisfying the AHP consistency criterion. These results demonstrate that the pairwise comparison judgments provided by the 26 experts are logically consistent, and that the calculated local weights at each hierarchical level are reliable, providing a robust quantitative foundation for evaluating ESG information disclosure quality in the agricultural chemicals industry.

4.2. Classification of Indicator Attributes and Design of the Three Value Scoring Method

The ESG indicator system developed in this study comprises two components, the framework level and the operational level. At the framework level, the system adopts the first-level and second-level indicators developed for the agricultural chemicals industry based on the GRI Standards, covering the Environmental (E), Social (S), and Governance (G) dimensions. This structure ensures consistency with international reporting principles while incorporating the specific characteristics of the agricultural chemicals industry. At the operational level, each third-level observation indicator is assigned an indicator type and evaluated using a three-point scoring system ranging from 0 to 2 points. The indicators are classified as qualitative (N type), quantitative (Q type), or mixed (M type), with each category subject to distinct scoring criteria. Table 8 presents examples of the three indicator types and their corresponding scoring requirements.

Table 8. Classification of Third-Level Indicators and Examples of the Three Value Scoring Criteria for the Agricultural Chemicals Industry.

Nature of the Indicator	Level 3 Indicators	Scoring Criteria
Qualitative Indicator (N) Based on the disclosure of narrative information, including management systems, procedures, policies, and records. No mandatory quantitative disclosure is required.	Development of management systems for clean energy procurement certification, carbon market compliance record-keeping, third-party carbon footprint verification and certification, and closed-loop recycling management of power batteries.	**0 points:** No corresponding management system or standardised implementation process has been established, no supporting management records are available, and the annual report or ESG report contains no relevant textual disclosures. **1 point:** Only basic written policies and compliance plans are disclosed. The disclosure merely satisfies the minimum regulatory requirements without implementation records, regular review or improvement mechanisms, or disclosure of adverse events. **2 points:** A fully implemented and standardised management system operates as part of routine practice. Complete operational records are maintained and archived, an annual review and continuous improvement mechanism has been established, relevant negative incidents are proactively disclosed, disclosure boundaries are clearly defined and comprehensive, and supporting third-party certification documents are provided.

Table 8. *Cont.*

Nature of the Indicator	Level 3 Indicators	Scoring Criteria
Quantitative Indicator (Q) Assessment is based on quantitative disclosure, including continuous values, quantities, proportions, and performance indicators.	Quantitative disclosure of clean energy utilisation ratios and energy composition; quantitative disclosure of the scale of self-developed wind, solar, and hydrogen energy projects; comprehensive greenhouse gas accounting; carbon emission intensity per unit of product; and detailed disclosure of individual greenhouse gas emissions.	**0 points:** No dedicated statistical records or annual calculated values are available, and the report contains no quantitative disclosures. **1 point:** Only fragmented baseline values for a single year are disclosed, without dimensional breakdowns or multi-year comparisons. No annual quantitative targets are established, resulting in limited data coverage and poor disclosure quality. **2 points:** Continuous and detailed quantitative data are disclosed over multiple years. Annual quantitative targets are clearly specified, year-to-year trends are presented, reporting boundaries are clearly defined, the data undergo internal review or third-party verification, industry benchmarking is supported, and annual target achievement is comprehensively reported.
Mixed Indicator (M) Assessment requires the combined disclosure of qualitative governance information and continuous quantitative data.	Coordinated management of annual clean energy substitution targets and their implementation; coordinated management and assessment of carbon reduction targets; coordinated management of carbon labelling for low-carbon products and its implementation; and coordinated management of the scale, operation, and maintenance of green logistics infrastructure.	**0 points:** No standardised quantitative data are available, no long-term management system has been established, and neither qualitative nor quantitative information is disclosed. **1 point:** Only one of the two disclosure requirements is satisfied, either quantitative data or basic governance arrangements. The other component is absent, meaning that only the minimum compliance threshold is achieved without coordinated management between governance policies and quantitative objectives. **2 points:** Both the quantitative and qualitative disclosure requirements are fully satisfied. Complete and verifiable quantitative data are provided, a long-term governance system operates effectively, quantitative objectives are integrated into routine management and assessment processes, and all disclosure quality requirements are fully met.

Note: All third-level observation indicators in this study were evaluated using a three-point scoring system (0–2 points), with 2 representing the highest disclosure quality. Indicator classification was based on a standardized coding manual to minimize bias in attribute classification. The scoring system considers key dimensions of disclosure quality, including completeness, accuracy, comparability, disclosure of negative events, and third-party assurance. To strengthen the consistency of the scoring process and reduce coder-specific subjectivity, all third-level indicators were independently evaluated by two coders using a standardized coding manual.

To facilitate the evaluation, benchmarking, and classification of ESG information disclosure quality among agricultural chemicals enterprises, this study develops a five-level grading system. The system is based on the equal-interval classification of the 0–2 scoring scale, while also reflecting the GRI disclosure quality framework, the structure of widely adopted ESG rating systems, and key characteristics of the agricultural chemicals industry, including high environmental risk, stringent regulatory requirements, and complex supply chain management. This approach is intended to enhance both the industry relevance and the comparability of the resulting ESG disclosure quality assessments. The corresponding score ranges, disclosure quality levels, and their approximate alignment with Huazheng ESG ratings are presented in Table 9. Importantly, the resulting thresholds should be

interpreted as operational benchmarking bands rather than as empirically estimated natural cut-points in the distribution of disclosure quality. Accordingly, companies with scores close to adjacent thresholds should not be regarded as substantively different solely because they fall into different disclosure-quality categories. The continuous ESG disclosure quality score should therefore be considered alongside the corresponding categorical classification.

Table 9. Quality Grading Standards for ESG Information Disclosure in the Agricultural Chemicals Industry Based on GRI Standards.

Score Range	Disclosure Quality Rating	Level Description	Approximate Correspondence to Huazheng ESG Ratings
1.80–2.00	Extremely High Disclosure Quality	The company demonstrates full compliance with the GRI disclosure framework by providing comprehensive disclosures across all ESG dimensions. Quantitative information is detailed, reporting boundaries are clearly defined, multi-year trend analyses and progress towards annual targets are disclosed, negative events and potential risks are reported proactively, selected information is supported by third-party assurance, and governance systems are well established and consistently implemented, resulting in industry-leading disclosure quality.	AA–AAA
1.60–1.79	High Disclosure Quality	The company provides comprehensive disclosures on the major ESG issues relevant to the agricultural chemicals industry. Most indicators are supported by quantitative information and include year-to-year comparisons. Governance systems are well established and effectively implemented. Although some sub-indicators could be reported in greater detail, the overall disclosure quality remains high.	BBB–A
1.40–1.59	Moderate Disclosure Quality	ESG disclosures are only partially complete. Some material agricultural chemicals-specific indicators are reported primarily through qualitative descriptions, while quantitative information is limited and lacks detailed breakdowns or trend analyses. Negative events and associated risks are not disclosed proactively, and governance mechanisms mainly support regulatory compliance rather than continuous improvement.	B–BB
1.20–1.39	Low Disclosure Quality	ESG disclosures are fragmented and lack a systematic structure. Many important industry-specific indicators are only briefly discussed or omitted entirely. Quantitative targets, year-to-year comparisons, and risk disclosures are largely absent, while governance mechanisms remain weak, resulting in poor overall disclosure quality.	CC–CCC
<1.20	Very Low Disclosure Quality	ESG disclosures fall substantially below the requirements of the GRI framework. Information relating to key environmental, supply chain, and product safety issues is largely absent. Quantitative information, risk disclosures, and corrective measures are missing, resulting in disclosure quality that is highly inadequate and unreliable.	C and below

Note: The grading criteria are aligned with the GRI disclosure quality evaluation framework and are designed to broadly correspond to the Huazheng ESG rating system. The correspondence is intended solely as an interpretative reference to facilitate understanding of the proposed grading system and does not imply a direct conversion between the two evaluation frameworks. The category thresholds represent operational benchmarking bands and should not be interpreted as empirically derived discontinuities in disclosure quality.

4.3. Case Study Analysis and Robustness Testing

4.3.1. Independent Holdout-Sample Validation

To provide an independent assessment of the effectiveness of the proposed indicator system, this study used the seven listed agricultural chemical companies that were excluded from framework development under the predefined two-year Huazheng rating criterion as a holdout validation sample. As shown in Table 1, each of these companies received a Huazheng rating of B in at least one of the two years and therefore did not meet the requirement of maintaining BB or above in both 2024 and 2025 for inclusion in the development sample. When subsequently assessed using the proposed disclosure-quality framework, the seven companies spanned a broad range of disclosure-quality classifications, from Very Low to Extremely High, thereby providing substantial variation for evaluating the framework's discriminative capability. Because these companies were not used at any stage of indicator screening or framework development, their application provides an independent within-population validation of the proposed framework. The analysis therefore evaluates the framework from two complementary perspectives: holdout-sample validation and internal robustness, as shown in Table 10.

Table 10. Comparison of Comprehensive Scores, Disclosure Quality Ratings, and Huazheng ESG Ratings for the Seven Validation Companies.

Company	Overall Score Range	Disclosure Quality Rating	Huazheng 2025 ESG Rating
Hubei Yihua Chemical Co., Ltd.	1.60–1.70	High Disclosure Quality	BBB
Xinyangfeng Agricultural Technology Co., Ltd.	1.50–1.59	Moderate Disclosure Quality	B
Lianhua Technology Co., Ltd.	1.83–1.90	Extremely High Disclosure Quality	B
Jinzhengda Ecological Engineering Group Co., Ltd.	1.50–1.58	Moderate Disclosure Quality	B
Hubei Xingfa Chemical Group Co., Ltd.	1.80–1.88	Extremely High Disclosure Quality	AA
Jiangxi Guangxin New Materials Co., Ltd.	1.50–1.57	Moderate Disclosure Quality	B
Shaanxi Meibang Pharmaceutical Group Co., Ltd.	1.10–1.19	Very Low Disclosure Quality	B

Note: This study used a dual-coder independent blind scoring procedure. For certain indicators, the 2025 sustainability reports of the seven companies provided only aggregated information, while detailed data for individual production sites or annual breakdowns were unavailable. Minor differences also arose between the two coders when interpreting a small number of ambiguous disclosures. Rather than imposing a single score where the underlying disclosure did not support an unambiguous judgment, the lower and upper plausible scores were retained. The Huazheng 2025 ESG rating is reported solely as a contemporaneous benchmarking reference. Membership in the validation sample was determined using the two-year selection criterion described in Section 3.1, under which companies were included in the development sample only if they maintained a Huazheng rating of BB or above in both 2024 and 2025.

As a benchmarking comparison, the disclosure-quality classifications obtained from the proposed framework show broad alignment with the overall pattern of the Huazheng 2025 ESG ratings, while also revealing important differences at the individual-company level. A comparison of the results for Lianhua Technology Co., Ltd. and Shaanxi Meibang Pharmaceutical Group Co., Ltd. illustrates a fundamental distinction between the two evaluation frameworks. The GRI-based ESG disclosure quality framework developed in this study differs substantially from the underlying objectives of the Huazheng ESG rating system. The proposed framework focuses specifically on the quality of ESG disclosures, assigning greater weight to industry-specific indicators such as agrochemical carbon footprint, hazardous waste management, and ecological performance. Lianhua Technology's sustainability report provides comprehensive carbon verification information

together with detailed year-specific quantitative disclosures, satisfying the highest disclosure quality standards and resulting in an Extremely High Disclosure Quality rating. In contrast, Shaanxi Meibang Pharmaceutical Group Co., Ltd. disclosed only basic compliance information, with limited reporting on climate-related and ecological issues. As a result, the company received zero scores for multiple indicators and was classified as having Very Low Disclosure Quality. By contrast, Huazheng ESG Ratings place greater emphasis on operational risk than on the quality and completeness of ESG reporting. Since neither company had experienced significant environmental penalties, both received the same Huazheng ESG rating of B.

This comparison demonstrates that, although the Huazheng ESG rating system can broadly distinguish corporate ESG risk, the industry-specific framework developed in this study provides a more detailed and discriminating assessment of ESG disclosure quality. Consequently, it addresses an important limitation of the Huazheng ESG rating system in evaluating the quality of corporate information disclosure.

4.3.2. Multi-Level Weight Perturbation Robustness Test

To evaluate the stability of the AHP weighting system and the ESG disclosure scoring model, this study conducted ±20% local weight perturbation tests at the criterion layer, across all first-level indicators, and for selected core second-level indicators. Following each perturbation, the comprehensive scores of the seven validation companies were recalculated. Ranking stability was then assessed using the midpoint of each company's score range as the baseline value. The midpoint was selected as a neutral representation of each interval because it incorporates both the lower and upper plausible estimates without systematically favoring either bound. As no tied rankings were observed among the seven companies based on these midpoint scores, Kendall's τ-a coefficient was used to evaluate ranking stability. The calculation is presented in Equation (9):

$$\tau = \frac{N_c - N_d}{C_n^2} \tag{9}$$

where

$$C_n^2 = \frac{n(n-1)}{2}$$

represents the total number of pairwise comparisons in the sample, N_c denotes the number of concordant pairs, and N_d represents the number of discordant pairs. A Kendall's τ value closer to 1 indicates greater ranking consistency and stronger model robustness.

The results of both the positive (+20%) and negative (−20%) weight perturbation tests were highly consistent, as presented in Table 11.

The Kendall's τ coefficients exceeded 0.89 across all hierarchical levels, indicating a high degree of ranking consistency throughout the validation sample. Only two companies, Jinzhengda Ecological Engineering Group Co., Ltd. and Jiangxi Guangxin New Materials Co., Ltd., exchanged adjacent ranking positions following adjustments to the governance dimension weights. This minor change can be attributed to the companies' very similar performance in three disclosure areas: greenhouse gas emissions, supplier environmental assessment disclosures, and social responsibility disclosures. Because their overall score ranges also overlapped considerably, their rankings were more sensitive to changes in the governance weights. As an additional sensitivity check, the lower and upper bounds of the reported score intervals were also considered. All seven companies retained the same disclosure-quality classifications under both bounds. The lower-bound scores resulted in a tie among three companies within the Moderate Disclosure Quality category, but no company shifted to a different disclosure-quality category. Consistent with this finding,

the ranking changes resulting from the weight perturbations occurred only within the Moderate Disclosure Quality category, while the classifications of companies outside this category remained unchanged. No ranking reversals occurred across disclosure-quality categories, further confirming the robustness of the proposed evaluation framework.

Table 11. Kendall's τ Statistics Following Weight Perturbations at Different Hierarchical Levels.

Hierarchical Level	+20% Perturbation (τ)	−20% Perturbation (τ)	Ranking Stability
Criterion Layer (Environmental, Social, and Governance)	0.972	0.968	Complete Stability
Environmental First-Level Indicators	0.951	0.945	High Stability
Social First-Level Indicators	0.936	0.930	High Stability
Governance First-Level Indicators	0.901	0.896	Overall Stability
Employee Development Second-Level Indicators	0.985	0.981	Complete Stability

Note: Kendall's τ was used to classify ranking stability. Values of $\tau \geq 0.95$ indicate complete stability, meaning that company rankings remain unchanged following weight perturbation. Values of $0.90 \leq \tau < 0.95$ indicate high stability, where only a very small number of adjacent position changes may occur within the same disclosure quality category, without any reversals between categories. Values of $0.85 \leq \tau < 0.90$ indicate overall stability, where only adjacent companies within the same disclosure quality category may exchange positions, while the overall conclusions regarding higher and lower disclosure quality remain unchanged. Values of $\tau < 0.85$ indicate substantial ranking instability, suggesting that cross-category ranking reversals occur and that the model lacks sufficient robustness.

5. Discussion

This study contributes to the growing ESG disclosure literature by demonstrating that the quality of sustainability reporting cannot be adequately assessed through universal reporting frameworks alone, particularly in industries characterized by significant environmental and social externalities. Although the GRI Standards provide an internationally recognized basis for sustainability reporting, the findings indicate that their practical value can be significantly enhanced when they are adapted to the operational characteristics and regulatory requirements of a specific industry (Leite de Almeida et al., 2025; Santana Tovar et al., 2025). Rather than replacing the GRI Standards, the proposed framework builds upon them by introducing a hierarchical industry-specific indicator framework comprising the ESG dimension layer and three indicator levels, together with a three-point scoring scale (0–2). This approach improves indicator relevance, scoring consistency, and decision usefulness within the agricultural chemicals sector. In doing so, the study responds to the growing recognition that internationally comparable ESG reporting must also remain sufficiently flexible to capture sector-specific sustainability issues (Christofi et al., 2025).

The prominence of the environmental dimension reflects not only the weighting process adopted in this study but also the material sustainability challenges that define the agricultural chemicals industry, where environmental impacts are directly associated with production processes, product safety, biodiversity, water management, pollution prevention, and hazardous chemical handling. In such sectors, stakeholders including regulators, farmers, and local communities naturally place greater emphasis on environmental accountability than on broad sustainability narratives. This observation is consistent with previous research suggesting that ESG priorities differ substantially across industries and should reflect sector-specific sustainability risks rather than generic reporting expectations (Jessop et al., 2019; Leite de Almeida et al., 2025). The findings from the seven validation companies further demonstrate this distinction. For example, Lianhua Technology achieved an Extremely High Disclosure Quality rating under the proposed framework despite receiving only a B rating from the Huazheng ESG Rating, whereas Shaanxi Meibang Pharmaceutical Group Co., Ltd. also received a B rating despite providing only limited sustainability dis-

closures. These findings suggest that generic ESG evaluation systems may underestimate the sustainability issues that are most material in environmentally sensitive industries. The results therefore reinforce the argument that effective ESG disclosure should be guided by materiality rather than by the application of uniform reporting criteria across fundamentally different industries. At the same time, the disclosure-quality categories should be viewed primarily as benchmarking aids rather than as discrete empirical groupings. Accordingly, small differences in continuous scores around adjacent category thresholds should not be interpreted as evidence of substantively distinct levels of disclosure quality.

Another important implication concerns the distinction between disclosure quantity and disclosure quality. The growing number of ESG and sustainability reports does not necessarily imply more informative reporting. Instead, the findings suggest that disclosure quality depends primarily on whether reported information captures issues that are genuinely material to business operations. By incorporating industry-specific indicators, including pesticide toxicology, ecological impact assessments, hazardous chemical management, biodiversity protection, and farmer support, the framework provides a more comprehensive assessment of sustainability disclosure than would be possible using generic indicators alone. This highlights that improvements in ESG reporting should focus less on expanding disclosure volume and more on increasing the relevance, specificity, and credibility of reported information. Particular attention should also be given to improving the use of quantitative disclosures and strengthening third-party assurance, as these elements enhance the transparency and reliability of sustainability reporting. Such an interpretation is consistent with previous research arguing that high-quality ESG disclosure reduces information asymmetry, enhances corporate resilience, and increases the usefulness of sustainability information for decision-makers (Reber et al., 2022; Ovais et al., 2025).

The governance findings provide further insight into the role that governance may play in supporting high-quality ESG disclosure. Rather than functioning solely as an independent reporting dimension, the findings can be interpreted as consistent with the view that governance provides an organizational foundation for credible environmental and social reporting. From this perspective, transparent governance structures, effective oversight mechanisms, and robust compliance systems may contribute to greater reliability and consistency in sustainability disclosures while reducing the potential for incomplete or symbolic reporting. Similarly, strong governance may facilitate the integration of sustainability principles into organizational decision-making, rather than treating ESG reporting merely as a separate disclosure exercise. However, effective ESG extends beyond formal organizational structures, committees, and compliance procedures. The existing literature further suggests that an ethical organizational culture that encourages employees to act responsibly beyond minimum compliance requirements may also be important. Research synthesizing evidence on integrity and organizational citizenship behavior demonstrates the relevance of these behavioral mechanisms in translating governance principles into consistent organizational practice (Saputra et al., 2026). Although this evidence originates from the public management literature, it highlights the broader governance principle that credible ESG disclosure may depend not only on formal governance arrangements but also on organizational behaviors that promote ethical conduct, accountability, and responsible decision-making. This interpretation is further reinforced by research on collaborative governance, which shows that effective risk governance depends on embedding risk management into routine organizational practices, cross-stakeholder coordination, and accountable decision-making rather than relying solely on formal governance structures or documented procedures (Purnama et al., 2026). Although these findings originate from a disaster risk governance setting, they illustrate a broader principle that is potentially relevant to ESG reporting: meaningful disclosure may be supported by governance systems

capable of translating sustainability commitments into coordinated organizational action. Together, these perspectives complement the findings of Shen et al. (2023), who argue that governance mechanisms play a central role in strengthening corporate sustainability practices and enhancing the credibility of ESG reporting. Accordingly, the findings suggest the potential importance of internal governance mechanisms and an ethical organizational culture for supporting sustainable business practices and stakeholder confidence in ESG disclosures.

From a theoretical perspective, the findings are consistent with propositions derived from stakeholder theory (Freeman, 2010) and legitimacy theory (Suchman, 1995) and demonstrate their conceptual usefulness in interpreting industry-specific ESG disclosure requirements. Stakeholder theory suggests that firms should disclose information that addresses the expectations of those most affected by their activities. In the agricultural chemicals industry, these expectations extend beyond investors to include regulators, farmers, local communities, consumers, and environmental organizations. The proposed framework is designed to address these diverse information needs by incorporating disclosure topics directly linked to agricultural production, environmental protection, and responsible supply chain management. In doing so, it enables a more comprehensive evaluation of the information that different stakeholder groups consider material for assessing corporate sustainability performance.

Legitimacy theory offers a complementary explanation by suggesting that firms operating in environmentally sensitive industries face greater pressure to demonstrate responsible behavior through transparent and credible sustainability reporting. Viewed through this theoretical lens, the findings suggest that disclosures addressing industry-specific sustainability challenges may be more consistent with the information needs and legitimacy pressures faced by such firms. Accordingly, industry-specific disclosure practices may contribute to organizational legitimacy by providing stakeholders with more relevant and decision-useful sustainability information.

Methodologically, the study integrates the targeted qualitative content analysis method (Hsieh & Shannon, 2005) with the Analytic Hierarchy Process (AHP) (Saaty, 1980, 1994), to establish a systematic and reproducible framework for developing industry-specific ESG disclosure indicators. The framework was developed through a sequential process that began with qualitative coding of corporate sustainability reports to identify substantive third-level indicators relevant to the agricultural chemicals industry, followed by expert-based AHP weighting and $\pm 20\%$ hierarchical weight perturbation analyses to evaluate the robustness of the weighting results. By combining qualitative indicator development with quantitative weighting and validation procedures, the proposed methodology addresses limitations associated with subjective indicator selection and insufficiently validated weighting methods, demonstrating how qualitative and quantitative approaches can be effectively integrated to develop balanced and industry-relevant ESG evaluation frameworks.

Beyond its methodological contribution, the study also highlights the inherent trade-offs associated with industry-specific ESG assessment. While specialized indicators improve the ability to capture material sector-specific sustainability risks, excessive customization may reduce cross-industry and cross-regional comparability. Conversely, fully standardized ESG criteria enhance horizontal comparability but may overlook sustainability issues that are particularly important within individual industries. The findings therefore support a hybrid approach that builds upon the GRI Standards while incorporating industry-specific indicators, thereby achieving an appropriate balance between international comparability and sector-specific relevance.

From a practical perspective, the proposed framework provides a structured assessment tool that can support multiple stakeholder groups. Regulatory authorities and

standard-setting organizations may use the framework to identify sector-specific disclosure gaps and refine industry-specific ESG reporting requirements. Listed agricultural chemical companies can employ it as a self-assessment instrument to benchmark disclosure quality, identify areas requiring improvement, and strengthen internal sustainability reporting practices. ESG rating agencies may use the framework as a complementary evaluation tool to enhance existing rating methodologies, while investors can use the resulting assessments to better evaluate the transparency, completeness, and credibility of corporate ESG disclosures when making investment decisions.

More broadly, these findings have implications for the future development of ESG reporting frameworks across industries. As international sustainability standards continue to evolve, regulators and standard-setting organizations face the challenge of balancing three competing objectives: maintaining international comparability, ensuring decision-usefulness, and adequately reflecting industry-specific sustainability risks. The "general benchmark plus industry-specific indicators" approach proposed in this study provides one possible solution by combining a common reporting foundation with sector-specific disclosure requirements. In doing so, it encourages ESG assessments to focus on genuinely material sustainability issues, enhances the practical usefulness of ESG reports for regulators and investors, and aligns with recent developments in the ESG reporting literature (Shen et al., 2023; Leite de Almeida et al., 2025; Santana Tovar et al., 2025).

6. Conclusions

Based on the findings of this study, industry-specific adaptation of internationally recognized ESG disclosure standards provides an effective approach for evaluating the quality of sustainability reporting in industries with significant environmental externalities. Drawing on the GRI 2021 Standards and integrating targeted qualitative content analysis (Hsieh & Shannon, 2005) with the Analytic Hierarchy Process (AHP) (Saaty, 1980, 1994), this paper develops an industry-specific environmental, social, and governance (ESG) disclosure quality evaluation framework tailored to the operational characteristics and regulatory requirements of China's agricultural chemicals sector. The framework combines qualitative indicator identification with quantitative expert weighting and employs a three-point scoring system ranging from 0 to 2, enabling a transparent and standardized assessment of disclosure quality. To facilitate interpretation and benchmarking, the continuous scores are further organized into five disclosure-quality categories. These categories should, however, be regarded as operational benchmarking bands, as their equal-interval thresholds do not represent empirically derived cut-points separating naturally distinct groups of companies.

The benchmarking comparison with Huazheng ESG ratings indicates broad alignment in overall patterns while also revealing important company-level differences. Rather than reproducing the outcomes of a general ESG rating system, the proposed framework provides complementary information by focusing specifically on the quality and industry relevance of ESG disclosures. By incorporating environmental, social, and governance sub-indicators tailored to the characteristics of the agricultural chemicals industry while remaining aligned with internationally recognized reporting standards, the framework provides a more context-sensitive assessment of ESG disclosure quality and highlights reporting differences that broader ESG ratings may not capture.

This study contributes to the existing ESG disclosure literature in three important ways. First, it advances the implementation of international reporting standards by demonstrating how the GRI Standards can be systematically adapted to reflect the material sustainability issues of the agricultural chemicals industry. Second, it introduces an integrated qualitative and quantitative methodological approach by combining targeted qualitative content analysis for indicator identification with AHP-based expert weighting, thereby providing

a transparent and standardized process for constructing industry-specific ESG disclosure indicators. Finally, it provides a standardized evaluation tool that can support regulatory authorities, listed agricultural chemical companies, investors, and other stakeholders in identifying disclosure gaps and improving sustainability reporting practices.

Despite these contributions, the findings should be interpreted in light of several limitations. First, the framework was developed using 10 companies selected from the complete eligible population of 17 Chinese listed agricultural chemical companies on the basis of maintaining a Huazheng ESG rating of BB or above in both 2024 and 2025. Although this criterion ensured sufficiently comprehensive disclosures for framework development, it may limit the framework's applicability to companies with less mature reporting practices and may introduce selection effects into the development stage. Second, although the framework was evaluated using a separate holdout validation sample and robustness analyses, both the development and validation samples were drawn from the same population of eligible Chinese listed agricultural chemical companies. Furthermore, the benchmarking exercise relies on comparison with a single external ESG rating provider, and the framework evaluates the quality of corporate ESG disclosures rather than verifying companies' underlying operational sustainability performance. Consequently, additional validation using independent datasets, alternative ESG rating systems, and companies operating in different institutional and industrial contexts would further strengthen confidence in the framework's generalizability and transferability beyond China. Third, the weighting process depends on expert judgment through the Analytic Hierarchy Process, which inevitably introduces a degree of subjectivity despite the use of structured expert selection procedures, independent consistency testing, and standardized weighting procedures. Fourth, while the proposed framework provides a comprehensive assessment of ESG disclosure quality through 350 third-level indicators, its practical implementation may require considerable time, expertise, and coding effort, potentially limiting its routine application without digital decision-support tools or automated text-analysis techniques. Finally, although a standardized coding manual and independent dual-coder assessment were employed to reduce coder-specific subjectivity and improve procedural consistency, inter-rater agreement was not formally quantified using a statistical reliability measure. This represents an additional limitation of the present study, as the extent of agreement between the two coders cannot be formally assessed. Future research should address this issue by retaining complete paired item-level coding records and reporting an appropriate inter-rater reliability statistic. Further research should also extend the framework to larger and more diverse samples, undertake fully independent out-of-sample validation, compare multiple ESG rating systems, assess coding reliability across independent coding teams, and examine its applicability across different industries and national contexts. Such research would contribute to the continued refinement of sector-specific ESG disclosure evaluation frameworks while achieving a more appropriate balance between international comparability, methodological robustness, practical applicability, and industry-specific materiality.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/admsci16080402/s1: Supplementary File S1. International and Chinese ESG Disclosure Standards, Frameworks, and Regulatory Documents Used in the Development of the ESG Disclosure Quality Assessment Framework. Supplementary File S2. Dictionary of Standardized ESG Disclosure Indicators for the Agricultural Chemicals Industry. Supplementary File S3. Survey Questionnaire on the Materiality of Indicators for the ESG Disclosure Quality Assessment System for the Agricultural Chemicals Industry Based on the GRI Standards.

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Data Availability Statement: The data supporting the findings of this study are available within the article and its Supplementary Materials. The Supplementary Materials include the expert questionnaire, the indicator dictionary, and other supporting materials used in the Analytic Hierarchy Process (AHP) and ESG disclosure evaluation. The study also draws on publicly available ESG reports from listed companies, Global Reporting Initiative (GRI) Standards, and publicly accessible policy documents.

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