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REGIONALIZED ESG METRICS FOR BRAZILIAN AGRIBUSINESS

MÉTRICAS ESG REGIONALIZADAS PARA O AGRONEGÓCIO BRASILEIRO

MÉTRICAS ESG REGIONALIZADAS PARA EL AGRONEGOCIO BRASILEÑO

ABSTRACT

Objective: This practitioner oriented article aims to develop regionalized ESG (Environmental, Social, and Governance) metrics for Brazilian agribusiness by adapting global indicators to regional specificities.

Methods: The research was conducted in three stages: mapping relevant ESG practices in agribusiness, reviewing international standards, and adapting these standards to meet the needs of the Brazilian sector. The study drew upon the last 20 years of academic research and global ESG reporting practices to underpin the proposal.

Results: The study proposed specific metrics, such as the ratio of deforested to preserved areas and greenhouse gas emissions per production unit, adjusted to the Brazilian context. The developed metrics not only enhance the quality of ESG disclosures but also promote greater transparency and accountability in the sector.

Conclusions: The proposed regionalized metrics offer a robust tool for internal company management, enabling the identification of risk and opportunity areas. The regionalization of ESG metrics strengthens the competitive position of Brazilian agribusiness in the global market and contributes to the sustainable development of agricultural regions in Brazil.

Keywords: ESG; Regionalized metrics; Brazilian agribusiness; Corporate governance.

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RESUMO

Objetivo: Este artigo tecnológico tem como objetivo desenvolver métricas ESG (Environmental, Social, and Governance) regionalizadas para o agronegócio brasileiro, adaptando os indicadores globais às particularidades regionais.

Métodos: A pesquisa foi conduzida em três etapas: mapeamento de práticas ESG relevantes no agronegócio, revisão de padrões internacionais e adaptação desses padrões às necessidades do setor no Brasil. Foram considerados os últimos 20 anos de pesquisa acadêmica e práticas de divulgação ESG globais para fundamentar a proposta.

Resultados: O estudo propôs métricas específicas, como a razão entre área desmatada e área preservada, e a emissão de gases de efeito estufa por unidade de produção, ajustadas ao contexto brasileiro. As métricas desenvolvidas não apenas melhoram a qualidade das informações ESG divulgadas, mas também promovem maior transparência e responsabilidade no setor.

Conclusões: As métricas regionalizadas propostas oferecem uma ferramenta robusta para a gestão interna das empresas, permitindo a identificação de áreas de risco e oportunidade. A regionalização das métricas ESG fortalece a posição competitiva do agronegócio brasileiro no mercado global e contribui para o desenvolvimento sustentável das regiões agrícolas do Brasil.

Palavras-chave: ESG; Métricas regionalizadas; Agronegócio brasileiro; Governança corporativa.

RESUMEN

Objetivo: Este artículo tecnológico tiene como objetivo desarrollar métricas ESG (Environmental, Social, and Governance) regionalizadas para el agronegocio brasileño, adaptando los indicadores globales a las particularidades regionales.

Métodos: La investigación se llevó a cabo en tres etapas: mapeo de prácticas ESG relevantes en el agronegocio, revisión de estándares internacionales y adaptación de dichos estándares a las necesidades del sector en Brasil. Se consideraron los últimos veinte años de investigación académica y de prácticas globales de divulgación ESG para fundamentar la propuesta.

Resultados: El estudio propuso métricas específicas, como la razón entre el área deforestada y el área preservada, y las emisiones de gases de efecto invernadero por unidad de producción, ajustadas al contexto brasileño. Las métricas desarrolladas no solo mejoran la calidad de la información ESG divulgada, sino que también promueven una mayor transparencia y responsabilidad en el sector.

Conclusiones: Las métricas regionalizadas propuestas ofrecen una herramienta sólida para la gestión interna de las empresas, permitiendo identificar áreas de riesgo y oportunidad. La regionalización de las métricas ESG fortalece la posición competitiva del agronegocio brasileño en el mercado global y contribuye al desarrollo sostenible de las regiones agrícolas de Brasil.

Palabras clave: ESG; Métricas regionalizadas; Agronegocio brasileño; Gobernanza corporativa

INTRODUCTION

In recent years, the concept of ESG (Environmental, Social, and Governance) has gained prominence in the corporate and financial world, expanding the focus of organizations beyond purely economic metrics (Gillan et al., 2021). This approach incorporates environmental, social, and governance factors that are essential for the long-term sustainability of companies and for generating shared value (Kim & Li, 2021).

The incorporation of ESG criteria into business strategies and investment decisions is driven by multiple factors. Evidence indicates that robust ESG practices are associated with better financial performance and risk mitigation (Wolfe, 2020), as well as the promotion of organizational resilience (Ashwin Kumar et al., 2016; Singhania & Saini, 2022). Simultaneously, the pressure from investors, regulators, and consumers for greater socio-environmental responsibility and corporate transparency is increasing (Altin & Yilmaz, 2023; Harper, 2020).

This global movement reflects the urgency of addressing challenges such as climate change, social inequality, and governance weaknesses

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(Aldowaisih et al., 2022), in line with the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement (ONU, 2000, 2015). In response, international and national regulators have been demanding more detailed and comparable ESG disclosures, as seen in the European Union (SFDR and EU Taxonomy), the United States (SEC), and Brazil (CVM) (Bengo et al., 2022; Carnini Pulino et al., 2022; South, 2023).

In this context, the International Sustainability Standards Board (ISSB) published the IFRS S1 and IFRS S2 standards, aimed at standardizing the disclosure of information on sustainability and climate risks (IFRS, 2023). Such standards seek to promote transparency, consistency, and comparability across corporate reports in different countries, strengthening the credibility of ESG practices (Cormac et al., 2023).

However, the direct adoption of these international standards presents significant limitations. The geographical, economic, and institutional diversity of countries imposes the need for contextual adaptations that consider the productive and regional characteristics of each sector (Eccles et al., 2012). Global metrics - although useful for benchmarking - do not always capture local nuances that influence companies' sustainable performance, especially in emerging economies.

In Brazilian agribusiness, this limitation becomes particularly evident. The sector is responsible for a significant share of the GDP and for integrating the country into global food chains (Kureski et al., 2020; Medina, 2022). However, its vast geographic diversity, heterogeneous climatic conditions, and regional socio-economic challenges demand specific indicators capable of reflecting the reality of production chains and the impact of sustainable practices on the territory (Rodrigues Moreira et al., 2016).

As currently available ESG metrics (originating from standards such as GRI, SASB, TCFD, IFRS, and IIRC) do not adequately contemplate these specificities. They prioritize a universalist perspective and, in many cases, treat agribusiness in an aggregated manner, without sensitivity to the regional and cultural variations that characterize the Brazilian sector. As a consequence, the reports produced by companies may lack comparability, relevance, and managerial usefulness, making it difficult to evaluate risks and opportunities from the perspective of investors and other stakeholders.

Given this gap, this practitioner-oriented article (Motta, 2017, 2022) begins with the identification of a practical problem (the absence of ESG metrics adapted to the regional realities of Brazilian agribusiness) and proposes an applied solution, based on the regionalization of ESG metrics and indicators for use in explanatory notes and sustainability reports.

The proposal recognizes the need to contextualize global ESG measures and to incorporate relevant local indicators capable of capturing dimensions such as water-use efficiency, ecosystem conservation, social inclusion, and transparency in governance. This regionalized approach seeks not only to strengthen the informational and accounting quality of companies but also to contribute to alignment between corporate practices and sustainable development objectives, promoting an integrated view of sustainability in Brazilian agribusiness.

CONTEXT AND INVESTIGATED REALITY

Brazilian agribusiness occupies a strategic position in the global scenario, standing out not only for its volume of production and exports, but also for its capacity for innovation and adaptation to new sustainability demands and social responsibility (Medina, 2022). The sector contributes significantly to the Gross Domestic Product (GDP), job creation, and the country's trade balance (Kureski et al., 2020), assuming an essential role in the global supply of food, fibers, and biofuels (Rodrigues Moreira et al., 2016).

Brazil is among the world's largest producers and exporters of agricultural commodities such as soybeans, maize, coffee, beef cattle, poultry meat, and orange juice (Mizobe, 2019). Soybeans, for example, are one of the main bases

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of human and animal nutrition, and the country leads global exports, mainly supplying the markets of China, Europe, and the United States (Filassi & de Oliveira, 2022). It is also the world's largest exporter of beef and the second-largest exporter of poultry meat, in addition to being responsible for approximately one-third of the world's coffee production (Ermgassen et al., 2020; Vartan, 2023).

The sector has invested in sustainable technologies, such as Integrated Crop-Livestock--Forest Systems (ICLFS) and precision agriculture, which promote the rational use of natural resources and reduce environmental impacts (Cisternas et al., 2020; Costa et al., 2018). ICLFS integrates agricultural, livestock, and forestry activities in the same area, diversifying production and increasing productivity with less pressure on the soil and water resources. Precision agriculture, through sensors, GPS (Global Positionins System), and drones, improves input management and the control of environmental variables, contributing to more efficient production with less impact.

Beyond its economic impact, agribusiness plays a relevant role in the social development of rural regions by generating millions of direct and indirect jobs and sustaining the income of various communities (Medina, 2022). The technological advancement and professionalization of the sector have promoted improvements in working conditions and strengthened corporate social responsibility programs aimed at education, health, and community development (Santos et al., 2021).

Despite these advances, structural and environmental challenges persist, threatening the competitiveness and international reputation of agribusiness. Illegal deforestation and environmental degradation, especially in the Amazon, remain sources of global concern and may create trade and reputational barriers (Rajão et al., 2020). In addition, the growth of production cannot occur to the detriment of ecosystems, requiring greater efficiency in the use of natural resources and production practices aligned with the mitigation of climate impacts (El Mahdy, 2021).

These challenges, however, also represent strategic opportunities. The growing demand for sustainable food and the global commitment to combating climate change position Brazil as a potential leader in low-carbon agriculture (Barbieri et al., 2014). The country's vast biodiversity and natural resources, when managed responsibly, allow the advancement of sustainable production systems with high international competitiveness.

Brazil has also strengthened its participation in multilateral initiatives focused on agricultural sustainability and food security, in partnership with international organizations such as FAO and the World Bank (Wittman & Blesh, 2017; Yeshanew, 2023). These co-operations contribute to the exchange of technologies and good practices, reinforcing Brazil's commitment to rural sustainable development and social inclusion.

However, consolidating this leadership requires adequate measurement and transparency tools. The absence of specific and regionalized ESG metrics and indicators for Brazilian agribusiness limits the accurate and comparable assessment of the sustainable performance of companies in the sector. Although widely accepted international frameworks exist, such as GRI, SASB, TCFD, IFRS and IIRC. These standards were developed in different contexts and do not fully reflect the productive, environmental, and social particularities of Brazilian regions.

As a result, ESG information is often reported inconsistently and with low comparability, which hampers performance analysis, the identification of improvement areas, and effective communication with investors and stakeholders. The lack of standardization reduces transparency and weakens the positioning of Brazilian agribusiness as a sustainability benchmark.

Given this gap, it becomes essential to develop ESG metrics adapted to the national reality, capable of translating the regional nuances of agribusiness and strengthening the credibility of accounting and sustainability information. This need underpins the proposal of this article, which seeks to contribute to the creation of a model of regionalized ESG indicators, oriented towards improving disclosure and promoting more responsible and competitive management in the sector.

DIAGNOSIS OF THE PROBLEM-SITUATION AND OPPORTUNITY

The concept of ESG represents a paradig-

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matic shift in the way companies are evaluated and managed. By incorporating environmental, social, and governance factors into corporate strategies, companies not only contribute to more sustainable development but also improve their resilience and long-term performance. The growing adoption of ESG practices by investors and companies is a clear signal that sustainability is becoming a central priority in the global corporate agenda.

The literature on measuring sustainable performance highlights that indicators derive from previously defined strategic objectives, reflecting each organization's environmental, social, and governance priorities (Hansen & Schaltegger, 2016; Pizzi et al., 2023). Thus, the construction of ESG indicators requires the clear identification of goals that guide business actions, allowing each metric to be associated with a measurable sustainability objective. This relationship ensures that indicators not only monitor results but also express coherence between the commitments assumed and the practices effectively implemented.

In the case of Brazilian agribusiness, such objectives are frequently linked to the mitigation of environmental impacts, the promotion of sustainable rural development, and the strengthening of corporate governance, serving as the foundation for the regionalized ESG metrics proposed in this study.

The environmental dimension of ESG refers to the impact of a company's operations on the natural environment. This includes the management of natural resources, greenhouse gas emissions, waste management, energy efficiency, and the sustainability of supply chains. Companies that adopt responsible environmental practices seek to minimize their negative impact on the environment through initiatives such as carbon reduction, the use of renewable energy, water conservation, and biodiversity protection (Miroshnychenko et al., 2017).

Investors and other stakeholders are increasingly aware of environmental issues and demand that companies demonstrate a commitment to sustainability (Zhou & Jin, 2023). The evaluation of a company's environmental performance may include indicators such as carbon footprint, the amount of renewable energy used, water efficiency, recycling, and the management of hazardous waste. In addition, innovative practices such as the circular economy, which aims at waste elimination and the continuous use of resources, are also highly valued (Suchek et al., 2021).

The social dimension of ESG encompasses a company's practices in relation to the people and communities with which it interacts. This includes aspects such as human rights, working conditions, diversity and inclusion, community impact, health and safety at work, and labor relations. Companies with strong social performance are those that promote fair and safe working environments, respect workers' rights, support diversity and inclusion, and contribute positively to local communities (Newman et al., 2020).

The importance of the social dimension is highlighted by the growing recognition that sustainable and responsible companies are those that not only seek profit but also contribute to the well-being of their employees and the communities in which they operate. Social indicators may include gender and ethnic diversity in the workforce, the existence of anti-discrimination policies, training and development programs, employee well-being initiatives, and community engagement (Sherman et al., 2021).

The governance dimension of ESG refers to management and administrative practices within the company. This includes the corporate governance structure, transparency, ethics, board accountability, protection of shareholder rights, anti-corruption policies, and the quality of financial disclosures. Companies with good governance practices are those that have clear and accountable leadership structures, robust compliance and ethics policies, and a high level of transparency and accountability (Breeze, 2021).

Thus, evaluating a company's ESG performance requires a detailed understanding of its practices and impacts across the environmental, social, and governance areas. Currently, there are 182 ESG criteria/indicators, including 78 environmental, 64 social, and 40 governance indicators, organized within a reference taxonomy (Sica et al., 2023). This is essential not only for investors but also for internal managers who need to continuously monitor and improve their ESG practices.

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The integration of ESG metrics and indicators into explanatory notes is also important for effectively managing risks and opportunities. Companies face a wide range of risks associated with environmental, social, and governance issues, which can significantly impact their financial performance and reputation (Kim & Li, 2021). Specific indicators allow companies to identify, assess, and manage these risks proactively.

The development of specific metrics and indicators for explanatory notes related to ESG is also essential to ensure regulatory compliance and corporate responsibility (Shapsugova, 2023). With the increasing introduction of ESG reporting regulations and requirements across various jurisdictions, companies need to provide detailed and accurate information about their ESG practices to meet these demands.

The need for specific metrics and indicators for explanatory notes related to ESG is widely recognized by several international initiatives and standards. Organizations such as the Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB), the Task Force on Climate-related Financial Disclosures (TCFD), and the International Integrated Reporting Council (IIRC) have developed frameworks and standards for the disclosure of ESG information (Kılıç & Kuzey, 2018; O'Dwyer & Unerman, 2020; Pizzi et al., 2023).

These standards provide guidance on the metrics and indicators that companies should report, promoting the standardization and comparability of ESG information. The adoption of these standards by companies can facilitate assessment by investors and other stakeholders, contributing to the integration of ESG criteria into investment decisions and corporate management.

However, a regionalized approach is essential to ensure the relevance and applicability of ESG metrics and indicators in specific sectors and regions, such as the Brazilian agribusiness sector. Each region of Brazil has unique characteristics, both in terms of natural resources and agricultural practices, local cultures, socioeconomic challenges, and climate conditions. Therefore, an approach that considers these particularities is essential for the development of effective ESG metrics that are truly useful for evaluating, monitoring, and improving sustainable and responsible practices in agribusiness. The following section provides a diagnosis highlighting the importance of regionalizing ESG metrics.

ENVIRONMENTAL AND CLIMATE DIVERSITY

Brazil is a country of continental dimensions, with extraordinary environmental and climate diversity. From the Amazon Rainforest, through the Cerrado, the Pantanal, the Atlantic Forest, the Caatinga, and the Pampa, each region has distinct ecosystems with different challenges and opportunities for agricultural production. For example, while the Amazon region faces significant challenges related to deforestation and biodiversity conservation, the Cerrado is known for its importance as a major grain-producing area, but also for its concerns regarding soil and water conservation. Agricultural practices suitable for these regions must be distinct, with specific indicators that reflect local needs and challenges. Therefore, metrics that are relevant in one region may not be appropriate or effective in another.

AGRICULTURAL AND TECHNOLOGICAL PRACTICES

Each region of Brazil has agricultural practices and technologies influenced by local traditions, empirical knowledge, and access to technological innovations. In southern Brazil, for example, agricultural practices are strongly influenced by grain cultivation and dairy production, while in the northeast, rainfed agriculture and the raising of goats and sheep predominate. The integration of different agricultural activities, such as integrated crop-livestock-forest (ICLF), also varies according to local conditions and resource availability. A regionalized approach allows the adaptation of ESG metrics to reflect these specific practices and technologies, promoting the adoption of innovations that are viable and effective in each context. Moreover, this helps to avoid the imposition of generic standards that may not be practical or effective for all producers, contributing to the development of more sustainable solutions adapted to local realities.

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SOCIOECONOMIC AND CULTURAL CHALLENGES

Socioeconomic and cultural challenges also vary significantly among Brazilian regions. Regions such as the northeast face challenges related to poverty, lack of access to basic services, and the need for social inclusion, while areas in the south and southeast deal with issues related to technological modernization and the management of large agricultural properties. Working conditions, human rights, health and safety in the workplace, and the interaction with local communities are aspects that must be addressed in a differentiated manner. A regionalized approach allows the development of metrics that consider these specificities, promoting practices that respect local cultures and that are sensitive to the needs and challenges of rural communities. This not only increases the effectiveness of the metrics but also strengthens the acceptance and engagement of producers and local communities with ESG initiatives.

REGULATORY AND NORMATIVE COMPLIANCE

Environmental and social legislation and regulations also vary among regions, reflecting different priorities and local contexts. While some areas may be subject to strict restrictions on land use and environmental conservation, others may have more flexible or specific policies to encourage sustainable development. In addition, labor and occupational safety standards may vary, requiring metrics that are adequate for each regulatory context. A regionalized approach ensures that ESG metrics are aligned with local legislation and regulatory requirements, facilitating corporate compliance with applicable norms and avoiding conflicts or misunderstandings. This also helps promote greater harmonization between business practices and legal requirements, strengthening sustainability and corporate responsibility in agribusiness.

IMPROVEMENT IN DATA QUALITY AND ACCURACY

The collection and analysis of ESG data are fundamental for the effectiveness of the metrics. However, data quality and accuracy may vary significantly among regions due to differences in infrastructure, producer training, and access to monitoring technologies. A regionalized approach allows the development of data collection methods adapted to local conditions, ensuring data quality and accuracy. For example, in remote or hard-to-access regions, it may be necessary to use specific technologies such as satellites, drones, or environmental sensors to monitor agricultural practices and environmental impacts. In areas with greater access to digital technologies, the use of online monitoring platforms and geographic information systems (GIS) may be more effective. The regionalization of metrics ensures that the collected data are relevant and useful for evaluating ESG performance, regardless of local conditions.

PROMOTION OF INNOVATION AND SUSTAINABLE DEVELOPMENT

The regionalized approach can also promote innovation and sustainable development in agribusiness. Each region has a unique potential to develop innovative solutions that meet its specific challenges. For example, the Amazon region may benefit from forest restoration technologies and agroforestry systems, while the Cerrado may explore new crop varieties adapted to the local climate and soil. Developing metrics that encourage regionalized innovation helps create a favorable environment for the development of sustainable technologies and practices that are not only viable but also effective for each context. This promotes knowledge transfer, applied research, and collaboration among different regions, strengthening the sector as a whole.

STRENGTHENING THE PARTNERSHIP AND COLLABORATION NETWORK

A regionalized approach facilitates the strengthening of partnership and collaboration networks among producers, companies, research institutions, universities, and civil society organi-

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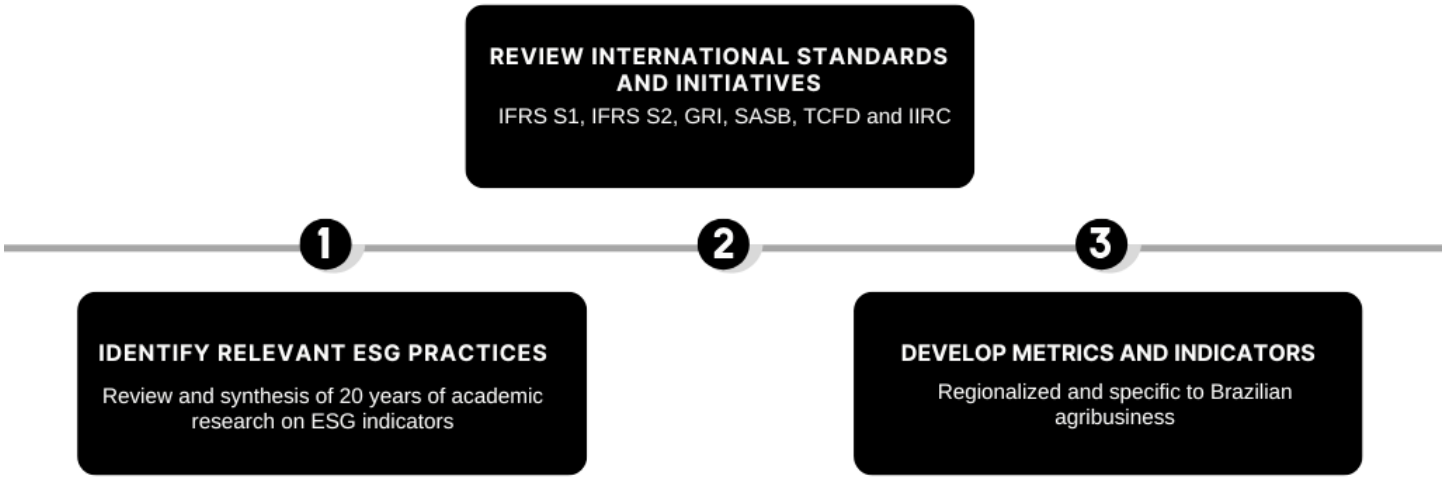
zations. These partnerships are essential for the development and effective implementation of ESG metrics, enabling the sharing of best practices, technologies, and knowledge. In addition, the regionalization of metrics promotes the active participation of local communities and producers, ensuring that their voices are heard and their needs considered during the development and implementation of the metrics. By developing metrics that respect these particularities, the Brazilian agribusiness sector can move toward more sustainable, responsible, and innovative practices, strengthening its position in the global market and contributing to a more sustainable and prosperous future for all. The regionalization of ESG metrics not only improves the effectiveness of agricultural practices but also promotes sustainable development and social inclusion, creating an agribusiness model that is truly sustainable and resilient.

ANALYSIS OF THE PROBLEM-SITUATION AND INNOVATION PROPOSALS

Metrics and indicators are essential tools for measuring, monitoring, and reporting corporate performance (Khan, 2018). These indicators provide a solid basis for decision-making, enabling companies to identify risks and opportunities, improve their practices, and respond effectively to the expectations of stakeholders. To achieve the objective of developing metrics and indicators specific to Brazilian agribusiness, this study was carried out in three stages, as shown in Figure 1.

Figure 1
Stages of the methodological procedure.



In the first stage, the most relevant ESG practices for agribusiness were mapped and analyzed, considering the particularities of the different production chains and regions of Brazil. This stage involved a review of the academic literature from the last 20 years on sustainability indicators and ESG reporting, with a time frame starting from the publication of the report Who Cares Wins (UN Global Compact, 2004). This reference marked the beginning of the global diffusion of the ESG concept as an integrated approach to environmental, social, and governance performance, providing a conceptual basis for the initial identification of the most recurrent practices in the sector.

The second stage consisted of a review and comparative analysis of international ESG reporting standards and initiatives, including IFRS S1 and IFRS S2 from the International Sustainability Standards Board (ISSB), the Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB), the Task Force on Climate-related Financial Disclosures (TCFD), and the International Integrated Reporting Council (IIRC). The objective of this stage was to identify convergences and gaps among these frameworks and adapt them to the needs and specificities of Brazilian agribusiness.

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Initially, the common thematic categories among the standards were mapped - such as greenhouse gas emissions, water use, biodiversity, working conditions, and corporate governance. Next, the metrics proposed by the GRI standards (notably GRI 300 - Environmental and GRI 400 - Social) were used as a comparison basis to identify indicators widely recognized and applicable to the sector. These metrics were compared with the regional and sector-specific particularities of Brazilian agribusiness identified in the first stage of the research, which enabled the regional adaptation of global parameters (for example, adjusting the metric "total energy consumption" to "energy efficiency per unit of agricultural production" or "GHG emissions per hectare").

From this integrative analysis, metrics with sectoral relevance, proven measurability, and regional applicability were selected, resulting in a set of regionalized ESG metrics aimed at accounting disclosure and improving transparency in Brazilian agribusiness.

In the third stage, the selected metrics underwent technical and contextual validation. This phase involved analyzing the coherence between the proposed indicators and the socioeconomic and environmental conditions of the main agricultural regions of the country, considering factors such as data availability, local regulations, and predominant production practices. The process sought to ensure that the metrics were both comparable and sensitive to regional realities, ensuring their practical usefulness for corporate management as well as for accounting disclosure purposes.

The result of these three stages was the development of a structured set of ESG metrics, combining theoretical analysis, comparison with international frameworks, and contextual validation. This sequence ensured that the proposed metrics were both comparable at a global level and aligned with the regional specificities of Brazilian agribusiness.

Although the present study was largely based on the main international ESG reporting frameworks (IFRS S1 and S2, GRI, SASB, TCFD, and IIRC) not all topics included in these standards were incorporated into the final set of regionalized metrics. This decision resulted from a filtering process guided by criteria of sectoral relevance, measurability, and regional applicability, as described in the methodology. Specifically in the case of the GRI standards, the topics most directly related to the externalities and material risks of Brazilian agribusiness, such as emissions, water use, biodiversity, labor rights, and corporate governance, were prioritized. Other topics - such as gender equality, organizational diversity, technological innovation, and post-consumption product impacts - although socially relevant, were considered of lower materiality for the scope of the research, either because they showed lower adherence to the typical operational practices of the sector or because they lacked systematic data at the regional level.

Thus, the absence of certain topics does not represent a theoretical gap but rather the result of a methodological delimitation aimed at constructing representative, measurable, and comparable metrics that can be effectively applied to the reality of Brazilian agribusiness, without compromising coherence with global frameworks.

Figure 2 is presented below, summarizing the set of regionalized metrics and indicators resulting from this process, highlighting their environmental, social, and governance dimensions and the adjustments applied to reflect the productive and institutional realities of the country.

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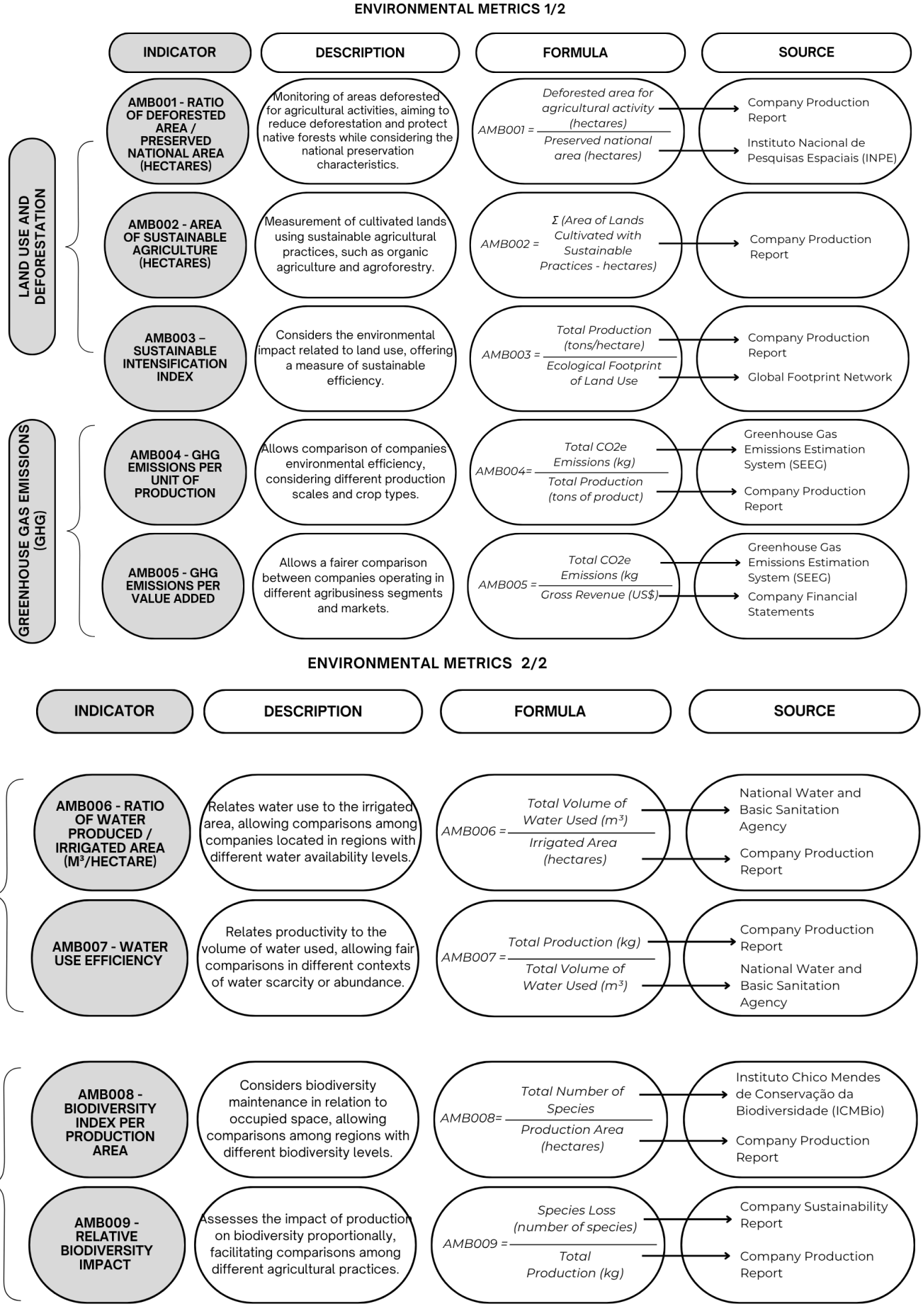
Figure 2

Proposal of Regionalized Metrics and Indicators Focused on Brazilian Agribusiness for Explanatory Notes in ESG Disclosure



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SOCIAL METRICS

	INDICATOR	DESCRIPTION	FORMULA	SOURCE
WORKING CONDITIONS	SOC001 - NUMBER OF WORKERS TRAINED IN SUSTAINABLE PRACTICES	Quantification of workers who receive training in sustainable agricultural practices and workplace safety.	$SOC001 = \sum(\text{Workers Who Completed Training in Sustainable Practices and Workplace Safety})$	Company Sustainability Report
	SOC002 - NUMBER OF JOBS CREATED PER PRODUCTION UNIT	Allows comparison of the social impact of companies, regardless of production size or type.	$SOC002 = \frac{\text{Total Number of Jobs Created}}{\text{Total Production (tons of product)}}$	O Cadastro Geral de Empregados e Desempregados (CAGED); Company Production Report
COMMUNITY DEVELOPMENT	SOC003 – INVESTMENT IN COMMUNITY DEVELOPMENT PER GROSS REVENUE	Relates companies' social investments to their economic capacity.	$SOC003 = \frac{\text{Investment in Community Development (US\$)}}{\text{Gross Revenue (US\$)}}$	Company Sustainability Report; Company Financial Statements
HUMAN RIGHTS	SOC004 - LABOR RIGHTS COMPLIANCE INDEX	Assesses compliance with national and international labor standards, relative to the number of workers and company size.	$SOC004 = \frac{\text{Number of Workers in Compliance with Labor Standards}}{\text{Total Number of Workers}}$	Ministério do Trabalho e Emprego (MTE); Company Financial Statements and Annual Reports
	SOC005 - INCIDENTS RELATED TO HUMAN RIGHTS EMPLOYEES	Quantifies the number of incidents related to human rights violations, adjusted for the total number of employees.	$SOC005 = \frac{\text{Total Number of Human Rights Incidents}}{\text{Total Number of Workers}}$	Ministério Público do Trabalho (MPT); Company Financial Statements and Annual Reports

GOVERNANCE METRICS

	INDICATOR	DESCRIPTION	FORMULA	SOURCE
TRANSPARENCY	GOV001 - EXTERNAL VERIFICATION INDEX OF SUSTAINABILITY REPORTS	Assesses the robustness and reliability of sustainability reports, considering external verification as a reflection of the company's transparency.	$GOV001 = \frac{\text{Número de Relatórios Verificados por Terceiros}}{\text{Número Total de Relatórios de Sustentabilidade}}$	External audit; Company Sustainability Report
	GOV002 - PUBLIC INFORMATION AVAILABILITY INDEX	Assesses the quantity of ESG-related information publicly available, adjusted to the complexity and size of the operation.	$GOV002 = \frac{\text{Número de Documentos de Sustentabilidade Acessíveis ao Público}}{\text{Número Total de Documentos de Sustentabilidade}}$	Company Sustainability Report; Company Sustainability Report
ETHICS	GOV003 - REGULATORY AND ETHICS COMPLIANCE INDEX	Evaluates the degree of companies' compliance with local and international ethics and regulatory standards, adjusted to regional realities.	$GOV003 = \frac{\text{Número de Conformidades}}{\text{Número Total de Normas Aplicáveis}}$	External audit; Pertinent legislation
STAKEHOLDERS	GOV004 - IMPLEMENTATION INDEX OF STAKEHOLDER RECOMMENDATIONS	Avalia a eficácia do Assesses the effectiveness of stakeholder engagement in terms of implementing their recommendations, adjusted by the complexity of the recommendations.	$GOV004 = \frac{\text{Número de Recomendações Implementadas}}{\text{Número Total de Recomendações Recebidas}}$	Internal Audit Reports; Advisory Board Meeting Minutes
	GOV005 - STAKEHOLDER SATISFACTION INDEX	Quantifies stakeholder satisfaction levels regarding the company's engagement practices, compared with global benchmarks.	$GOV005 = \frac{\sum(\text{Avaliações de Satisfação dos Stakeholders})}{\text{Total de Stakeholders Consultados}}$	Stakeholder Satisfaction Survey; Stakeholder Satisfaction Survey

DOI: https://doi.org/10.14210/alcance.v32n3(set/dez).pxx-xx

The final list of regionalized metrics and indicators was developed based on a filtering and convergence process among the international frameworks analyzed (IFRS S1 and S2, GRI, SASB, TCFD and IIRC) and the specificities identified in the diagnosis of Brazilian agribusiness.

Initially, the metrics included in the international standards were classified into environmental, social, and governance categories. Then, selection criteria were applied based on:

(i) sector relevance, considering the incidence of the topic in agribusiness;

(ii) measurability, meaning the possibility of measurement using available public or corporate data;

(iii) regional adherence, ensuring the applicability of the metrics to the different geographical and productive realities of Brazil; and

(iv) accounting usefulness, related to the capacity to include the metrics in explanatory notes or ESG reports.

After applying these criteria, the resulting metrics were validated regarding coherence and non-overlap, forming the final set presented in Figure 2. To reinforce methodological traceability, a summary table is presented below, linking each metric to its main normative source or original international standard, as well as the justification for its adaptation to the Brazilian context.

Figure 3
Summary Table

Dimension	Proposed Metric / Indicator	International Source / Reference	Justification for Adaptation to Brazilian Agribusiness	Associated SDG (Sustainable Development Goal)
Environmental	Greenhouse gas (GHG) emissions per production unit	GRI 305 / IFRS S2 / TCFD	Allows measurement of the intensity of emissions considering different production chains; enables fair comparison across regions and agricultural crops.	Reduce emissions and promote energy efficiency in agricultural operations. (SDG 13 – Climate Action)
Environmental	Ratio between deforested area and preserved area	SASB / GRI 304	Essential indicator to assess impacts on biodiversity and land use; adjusted to the reality of Brazilian biomes (Amazon, Cerrado, Caatinga etc.).	Conserve terrestrial ecosystems and curb deforestation. (SDG 15 – Life on Land)
Environmental	Water use efficiency (volume used per production unit)	GRI 303 / SASB	Reflects the critical nature of water resources and variation in availability across regions; highlights good irrigation practices and sustainable water management.	Ensure sustainable water use in agricultural production. (SDG 6 – Clean Water and Sanitation)
Environmental	Sustainable intensification index (integrated crop-livestock-forest use – ILPF)	Adapted from GRI 302 / FAO	Captures innovative and integrated land-use practices in Brazilian agribusiness; encourages low-impact productive systems.	Promote sustainable agriculture and efficient land use. (SDG 2 – Zero Hunger and Sustainable Agriculture)
Social	Percentage of workers trained in sustainable practices and safety	GRI 404 / SASB	Measures companies' commitment to training a qualified workforce and improving the well-being of rural workers.	Promote decent work, safety, and continuous qualification. (SDG 8 – Decent Work and Economic Growth)
Social	Compliance index with labor rights and working conditions	GRI 401 / GRI 412	Reinforces compliance with labor standards and human rights, especially in vulnerable rural regions.	Ensure decent working conditions and respect for human rights. (SDG 8 and SDG 10 – Reduced Inequalities)
Social	Investment in community development relative to gross revenue	GRI 413	Shows the companies' social commitment to local communities and sustainable rural development.	Strengthen community development and social inclusion in rural areas. (SDG 1 and SDG 11 – Sustainable Communities)
Governance	Existence of anti-corruption policy with annual public reporting	GRI 205 / IIRC	Strengthens transparency and integrity in production chains, especially in operations involving international markets.	Promote ethical governance, integrity, and combat corruption. (SDG 16 – Peace, Justice, and Strong Institutions)
Governance	ESG transparency and reporting index (disclosure of explanatory notes)	IFRS S1 / IIRC	Directly related to accounting and highlights the degree of companies' compliance with ESG disclosure standards.	Increase transparency and corporate accountability. (SDG 12 – Responsible Consumption and Production)
Governance	Participation of local stakeholders in decision-making processes	GRI 102 / SASB	Measures the degree of engagement and dialogue with local actors, reinforcing the legitimacy and participatory governance in agricultural regions.	Encourage social participation and stakeholder engagement. (SDG 17 – Partnerships and Implementation Means)

DOI: https://doi.org/10.14210/alcance.v32n3(set/dez).pxx-xx

As shown in Figure 3, each proposed metric is associated with corresponding sustainability objectives, in order to demonstrate the measurement purpose and the connection with the sector's strategic commitments. This association allows the metrics to function not only as performance measures but also as instruments for monitoring environmental, social, and governance goals aligned with the 2030 Agenda and international ESG reporting practices.

The ESG metrics proposed in this study were developed with the flexibility needed to adapt to different regional contexts, considering factors such as resource availability, local regulations, cultural practices, and socioeconomic conditions. By adapting the indicators to the specific characteristics of each region, we ensure that these indicators not only capture regional nuances but also enable fair and balanced comparison across different regions.

For example, the water-use efficiency indicator is adjusted to reflect variations in water availability in regions with water scarcity, such as the Brazilian Northeast, compared with regions that are more abundant in water resources, such as the South of Brazil. This type of adjustment allows the performance of companies in distinct geographic contexts to be compared equitably, taking into account their local limitations and opportunities.

In addition, the regionalization of governance metrics ensures that differences in local regulations, such as anti-corruption or transparency practices, are considered, allowing companies from different regions to be compared based on their specific challenges. This provides a clear and comparable overview of ESG performance in different parts of Brazil and potentially in other countries, promoting continuous improvement and encouraging best practices, regardless of the local context.

Thus, regionalized metrics not only encourage accurate local application but also provide a solid foundation for interregional ESG performance comparisons, allowing decision-makers and investors to assess the fairness and sustainability of practices in various contexts.

CONCLUSIONS AND TECHNOLOGICAL/SOCIAL CONTRIBUTION

The proposal for developing regionalized ESG metrics and indicators for the Brazilian agribusiness sector, with a focus on explanatory notes, presents a significant contribution both for organizations and for society as a whole. This proposal addresses the need to adapt global metrics to regional particularities, enabling a more accurate and fair assessment of sustainability practices in the Brazilian context. By creating indicators that contextualize environmental, social, and governance impacts according to the specificities of the sector and the region, the study not only improves the quality of ESG information disclosure but also promotes greater transparency and corporate responsibility in the agribusiness sector.

For organizations in the Brazilian agribusiness sector, adopting these metrics will allow a more equitable comparison with companies from other regions of the world. This becomes fundamental in a global scenario where pressure for sustainable practices continues to intensify, and companies must demonstrate compliance not only with local standards but also with international expectations. The proposed metrics, such as the ratio between deforested area and preserved area, and greenhouse gas emissions per production unit, provide a robust way to measure and communicate operational sustainability, adjusting assessments to Brazil's specific conditions.

Furthermore, these metrics offer a strategic tool for the internal management of companies, enabling a clearer identification of risk areas and opportunities in terms of sustainability. Water management, for example, is a critical issue in Brazil, especially in regions with water scarcity. The water-use efficiency indicator, which contextualizes productivity relative to water volume used, provides a solid basis for decision-making regarding investments in irrigation technologies and other water management practices.

In the social context, the proposed metrics play a vital role in promoting fair labor practices and protecting human rights. Indicators such as the number of workers trained in sustainable agricultural practices and the compliance index with labor rights not only encourage com-

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panies to improve their practices but also help raise the standard of living for local communities. By linking economic development to social well-being, these metrics contribute to the sustainable development of agricultural regions in Brazil.

Social implications are also evident in the metrics related to community development and stakeholder engagement. The proposed indicators, such as investment in community development relative to gross revenue and the stakeholder satisfaction index,promote a more inclusive business model, in which the needs and expectations of local communities are considered in corporate strategies. This not only strengthens the social license to operate but also creates a more harmonious and cooperative environment between companies and communities.

The regionalization of ESG metrics opens new opportunities for innovation in Brazilian agribusiness. The creation of indicators such as the sustainable intensification index and the biodiversity impact index encourages companies to explore innovative agricultural practices that increase productivity while minimizing environmental impact. This approach can catalyze the development and adoption of green technologies, regenerative agricultural practices, and other methods adapted to Brazil's unique conditions, but that may also serve as models for other regions.

In addition, the emphasis on transparency and compliance with ethical and anti-corruption standards strengthens corporate governance, reducing risks associated with illegal practices and increasing investor and consumer trust. By enabling a fairer and more contextualized assessment of sustainability practices, these metrics can help companies improve their competitive position in the global market, attract investments, and create long-term value.

The implementation of these metrics and indicators can generate positive outcomes both for organizations and for the environmental and social context in which they operate. In the long term, the adoption of sustainable practices encouraged by the proposed metrics can contribute to mitigating climate change, conserving biodiversity, and improving the living conditions of rural communities. The regionalization of ESG metrics ensures that sustainable practices are not viewed as external impositions but as opportunities for innovation and growth aligned with the real conditions of Brazilian agribusiness.

Thus, the proposal for regionalized ESG metrics for Brazilian agribusiness represents a significant contribution to promoting sustainability practices that are globally comparable and locally relevant at the same time. These metrics not only help companies improve their practices and position themselves better in the global market, but also contribute to the sustainable development of agricultural regions in Brazil, fostering a more resilient and equitable economy.

Although this study has focused on the design and systematization of regionalized ESG metrics for Brazilian agribusiness, it is acknowledged that the practical implementation stage represents a relevant step to consolidate the applicability of the proposed indicators. The operationalization of these metrics in real organizational environments may require a structured action plan capable of guiding companies and managers in the effective adoption of indicators and in integrating results into decision-making processes and financial reporting. However, such deepening does not fall within the scope of this article, whose focus lies in the conceptual and methodological development of the metrics.

As suggestions for future research, it is believed that this study can be complemented in stages. In a first step, it can be expanded through consultations with stakeholders, such as interviews and workshops with sector stakeholders, including agricultural companies, producer associations, investors, regulators, and civil society organizations, in order to identify relevant practices and validate the proposed indicators.

In a second step, progress can be made toward building a structured action plan, articulating implementation and continuous monitoring models, as suggested by approaches such as those of Soares et al. (2025). Thus, the present study provides a conceptual and instrumental foundation upon which ESG management and evaluation strategies can be developed for Brazilian agribusiness.

Furthermore, in a third step, progress can be made toward validating and testing the proposed indicators through case studies, adjusting

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them as necessary to ensure their relevance and applicability. Finally, after validation, it becomes possible to develop guidelines and recommendations for implementing ESG metrics and indicators in agribusiness, promoting the adoption of best practices and the continuous improvement of ESG performance

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