Revista Catarinense da CIÊNCIA CONTÁBIL
ISSN 2237-7662, v. 25, 1-23, e3678, 2026
https://doi.org/10.16930/2237-7662202636782
Available at http://revista.crcsc.org.br

READABILITY OF SOCIAL AND ENVIRONMENTAL INFORMATION IN THE AGRIBUSINESS SECTOR (2015–2024): AN ANALYSIS OF COMPANIES LISTED ON B3 WITH THE SUPPORT OF ARTIFICIAL INTELLIGENCE

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ABSTRACT

Agribusiness operates as an integrated system, and this dynamic requires strategic guidance grounded in sustainability practices. The objective of this article is to analyze the readability level of social and environmental information disclosed by companies in the agribusiness sector. This study adopts a quantitative approach based on content analysis. The sample comprises 23 publicly traded Brazilian agribusiness companies listed on B3, covering the period from 2015 to 2024. Text Readability Analysis, using the Flesch Index, was employed to assess the degree of clarity and accessibility of the texts. The operationalization of the study's empirical analysis was supported by Artificial Intelligence through a Python script developed in Google Colab and integrated with the Google Gemini model, a feature that represents one of the study's main methodological contributions. The study hypothesis was tested using fixed-effects panel data regression analysis. Audit type emerged as a factor positively associated with readability. In practical terms, this finding suggests that companies in the sample audited by a Big Four firm exhibited, on average, better readability indicators.

Keywords: sustainability, ESG, readability.

Edited in Portuguese and English. Original version in Portuguese.

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Received on November 18, 2025. **Final version received** on April 24, 2026. **Accepted on** April 28, 2026 by Rogério João Lunkes. **Published on** May 29, 2026.

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1 INTRODUCTION

Agribusiness, a sector encompassing agricultural activities from production to food distribution, operates as an integrated system, and its interdependence with sustainability has become essential for global food security and economic development (Pani et al., 2020). Climate variability caused by human activities poses a direct threat to food security, making it necessary to understand how the agricultural sector can adapt (Zulfikri et al., 2024). To achieve sustainability, agribusiness must ensure that its operations are financially viable while preserving the environment and maintaining a commitment to social well-being throughout all stages of production (Zulfikri et al., 2024).

These arguments are aligned with the Environmental and Social (ES) perspective, which has gained prominence both in the corporate environment (Gregory, 2023) and within the investment fund industry (Guimarães & Malaquias, 2023). Consequently, organizations increasingly place emphasis on sustainability, motivating the implementation of strategies that consider environmental impacts and may generate a set of actions capable of producing social and collective benefits (Freitas & Crisóstomo, 2021). The implementation of the Sustainable Development Goals (SDGs), together with integrated efforts across different levels, may contribute to mitigating these global challenges and fostering sustainable development (Mensah, 2019).

Readability is a measure that reflects the reader's ability to understand the intended message and is associated with the clarity and ease with which a document can be interpreted by its target audience (Moreno et al., 2023; Smaili et al., 2023). Readability refers to the degree of ease with which a text can be understood and may be enhanced through strategies involving verbal and visual resources aimed at making information more accessible and comprehensible to non-specialized audiences (Luzón & Albero-Posac, 2025; Moreno et al., 2023; Martins et al., 2025).

Readability represents a strategic priority for decision-makers because excessive complexity in disclosures may compromise informational clarity and negatively affect organizational image (Smaili et al., 2023). At this point, the Upper Echelons Theory (Hambrick & Mason, 1984) argues that managerial characteristics may be associated with the level of disclosure provided by firms, which may also extend to the readability of disclosed information. In light of the context in which agribusiness operates, particularly in the case of publicly traded companies, as well as considering the growing demand for sustainability-related information, this study seeks to address a gap by relating disclosure practices to the readability of social and environmental information. Furthermore, it aims to expand the scope of this research agenda through the integration of Artificial Intelligence resources into the methodological stage of the study in order to evaluate the readability of social and environmental information disclosed by companies.

Based on the context presented, the following research question is proposed: what is the level of readability of social and environmental information disclosed by companies in the agribusiness sector? In line with this research question, **the primary objective of this study is to analyze the readability level of social and environmental information disclosed by companies in the agribusiness sector**. In this context, the reports analyzed include explanatory notes, management reports, and sustainability reports. The analytical focus was concentrated on the Environmental and Social (ES) pillars because the reports were found to provide relevant evidence for this study within the environmental and social dimensions. In contrast, the Governance pillar, although centered on leadership structures and corporate objectives, appears less tangible for the proposed objective, in accordance with the methodological approach adopted by the study of Guthrie and Abeysekera (2006). Therefore, this research specifically focuses on the Environmental and Social (ES) components. The innovative approach provided by this study lies primarily in the use of Artificial Intelligence as a supporting tool for the analysis of corporate reports. Since the findings involve social and environmental aspects, the results may contribute to expanding

previous research on the topic, particularly by focusing on the readability analysis of such information.

Voluntary sustainability disclosure has been increasing, attracting both academic and market interest (Tsang et al., 2023). This study seeks to contribute to the Upper Echelons Theory by highlighting that the recruitment of managers should take into account their alignment with organizational standards and culture, since both observable and unobservable characteristics of these professionals may significantly influence the level and quality of information disclosed by the company.

Clear and accessible disclosure strengthens stakeholder trust, enhances organizational legitimacy, and reinforces corporations' social commitment. Furthermore, sustainable business success depends not only on economic performance but also on the ability to meet stakeholders' expectations and balance social, economic, and environmental impacts while respecting the specific characteristics and needs of each context (Trang et al., 2025). In this regard, the present study offers a social contribution by raising awareness among agribusiness companies regarding the importance of readability in communicating their sustainable practices through annual reports. Textual narrative represents a substantial portion of corporate reports, suggesting that the clarity and presentation of information are essential components for ensuring that reports can be properly understood (Malaquias & Silveira, 2020).

The following section is dedicated to the theoretical framework, presenting the underlying theoretical foundations. Subsequently, the methodological procedures are outlined, including the description of the sample, data collection techniques, variable operationalization, and data analysis strategies. Finally, the last section presents the analysis and discussion of the findings, consolidating the final considerations.

2 LITERATURE REVIEW

The quality of a report depends on its accessibility and clarity for all readers (Hu et al., 2024). Despite advances in readability research, there remains a gap in understanding the information disclosed by companies. In this context, Panta and Panta (2023) examine the relationship between organizational capital and readability, arguing that clear communication can improve reporting quality and strengthen financiers' trust. Readability, when associated with social and corporate governance practices, benefits all stakeholders by enabling more accurate decision-making. The implementation of environmental practices may improve report clarity, thereby strengthening business performance (Novianri et al., 2023). Rajabalizadeh and Schadewitz (2025) argue that reports that are easier to understand contribute to better market functioning; for this reason, they recommend that regulatory bodies establish clearer rules to improve reporting practices.

According to Amiran and Jones (1982), traditional readability metrics based on superficial aspects, such as word and sentence length, fail to capture the actual difficulty of textual comprehension. The authors therefore propose a three-dimensional approach encompassing structure, texture, and content density (Amiran & Jones, 1982). Structure refers to the organization and interconnection of textual components; texture concerns the degree of explicitness, namely the amount of inference required from the reader; and density indicates the volume of information that must be processed (Amiran & Jones, 1982). A text becomes difficult when it exhibits high informational density, even if its structure is clear and its texture explicit. Since readability formulas are based on word and sentence length, they can be applied to any alphabetic language, providing an automatic and objective method for comparing distinct texts and estimating the reading effort required (Matricciani, 2023). Sustainability disclosure reports corporate performance while promoting transparency and environmental accountability (Zuraida et al., 2024).

Alivia et al. (2020) analyzed how readability in disclosure affects investor attraction and decision-making processes within organizations, concluding that cognitive complexity hinders investors' ability to make informed investment decisions. In other words, companies should adopt less complex reporting criteria so that both numerical and narrative information can be properly understood and facilitate effective comprehension (Nguyen et al., 2023). Information disclosure may be viewed as a communication bridge between management and shareholders, particularly in publicly traded companies where a separation exists between owners and managers (Luo et al., 2018). Companies face increasing pressure to disclose environmental and social information; however, substantial variation remains in both the extent and readability of such disclosures (Conca et al., 2021).

Moreover, litigation encourages greater transparency in disclosure practices within regulated markets, whereas in contexts with lower regulatory requirements, such motivation tends to be reduced (Iftikhar et al., 2025). Sustainable practices have become central to investment decisions, reflecting growing concerns regarding sustainability. However, investors still face difficulties due to the scarcity and poor quality of disclosed information (Ilhan et al., 2023). To address investors' demand for environmental and social data, there has been a global movement requiring companies to disclose such information in a standardized manner within financial reports (Krueger et al., 2024).

To support the understanding of factors that may affect readability, the theoretical foundation adopted in this study is the Upper Echelons Theory, according to which managers' demographic and cognitive characteristics directly influence their strategic decisions, affecting both organizational performance and the manner in which information is disclosed to the market (Hambrick & Mason, 1984). The managerial characteristic considered in this study refers to educational background. According to Upper Echelons Theory, the relationship between managerial experience and strategic decisions is complex because executives are often selected precisely due to possessing profiles and career trajectories aligned with objectives defined by controlling entities (Hambrick & Mason, 1984). The theory suggests that organizational outcomes partially reflect managers' experiences, although these experiences may themselves result from previous organizational decisions (Hambrick & Mason, 1984). Observable and unobservable managerial characteristics influence the quality of organizational disclosure (Oliveira & Garcia, 2024). Upper Echelons Theory has served as a conceptual bridge for understanding how factors such as personality, values, and experiences shape strategies within organizational environments (Garcia & Oliveira, 2024).

Managers exert direct influence over organizational dynamics, particularly regarding the definition of strategies aimed at improving corporate performance (Garcia & Oliveira, 2024). Their influence also extends to how information is presented and perceived, especially through the use of visual elements (Crossley et al., 2022). In this study, an effort was made to relate the arguments of Upper Echelons Theory to the readability of environmental and social information disclosed by agribusiness companies. The agribusiness sector faces pressure at multiple levels to adopt appropriate environmental practices, including regulatory requirements such as CVM Resolution No. 193/2023, ranging from governmental and regulatory spheres with specific environmental legislation to sustainability expectations imposed by customers and suppliers (Amara & Chen, 2021; Taderka et al., 2013). Within this context, the regulatory system acts as a driver of innovation and competitiveness, encouraging companies to improve their processes in order to comply with established standards (Amara & Chen, 2021).

The Brazilian agribusiness sector is also increasingly exposed to international requirements regarding transparency and environmental traceability, whether through global value chains or consumer markets that monitor deforestation, land use, greenhouse gas emissions, and related issues (Rocha et al., 2025). A global movement among standard-setting bodies has been observed,

aimed at requiring companies to provide more detailed information concerning corporate management and environmental matters (Conca et al., 2021; Medina, 2022; Ramos & Herrera, 2024).

One development that has significantly affected the sector in this area is IFRS S2, *Climate-related Disclosures*, whose purpose is to require companies to disclose information concerning environmental risks and opportunities that may affect cash flows, access to financing, and cost of capital (Khatib, 2024). Brazilian agribusiness reaffirmed its strategic importance in 2024, accounting for 23.2% of national GDP and generating a total of R$ 2.72 trillion (MAPA, 2024). In international trade, Brazil consolidated its position as an agro-industrial powerhouse, with sector exports reaching US$ 164.4 billion (MAPA, 2024). This performance represented nearly half of the country's total exports, highlighting Brazil as one of the world's leading commodity suppliers, reaching as much as R$ 1.215 trillion and demonstrating the diversification and productive strength of agribusiness (MAPA, 2024).

The publication of understandable annual reports serves as an indicator that managers are committed to high ethical standards, and companies producing clearer and more accessible reports may be considered more ethically responsible (Smaili et al., 2023). Once again, the role of Upper Echelons Theory should be emphasized within this context, reinforcing the influence that managerial characteristics may exert on reports published by firms. Thus, this study may contribute by enabling investors to better assess sustainability-related risks and opportunities, thereby supporting more informed organizational decision-making.

Based on the literature reviewed, it can be observed that the readability of corporate reports extends beyond established metrics and encompasses structural characteristics and informational rigor. In the context of sustainability disclosure, informational clarity is viewed as a strategy for reducing information asymmetry and supporting investment decisions. Furthermore, institutional factors and regulatory pressures influence the level of transparency adopted by companies. In light of Upper Echelons Theory, managerial characteristics may also affect the quality and form of disclosure. In this study, managerial educational background was considered as a managerial characteristic, under the argument that education in management-related fields may contribute to the publication of reports with higher readability levels. The use of this variable is therefore aligned with Upper Echelons Theory. Accordingly, the following research hypothesis is proposed:

H1: Managerial educational background in the field of management exerts a significant effect on the readability level of ESG information.

Organizations reflect the cognitive characteristics and values of their managers. Consequently, strategic decisions, including the way socio-environmental information is disclosed, are influenced by organizational and structural attributes that shape incentives, monitoring mechanisms, and transparency. In this context, the readability of social and environmental information is understood as a strategic attribute of corporate disclosure capable of reducing information asymmetry and strengthening relationships with stakeholders.

Variables such as firm size, audit type (BIG4), return on assets (ROA), leverage, and firm age operate as structural mechanisms influencing the degree of informational clarity. Therefore, these variables were incorporated into the quantitative model as control variables. Larger companies and firms audited by BIG4 entities tend to face greater external scrutiny, which may encourage the production of more understandable reports. Likewise, financial performance, capital structure, and organizational maturity may influence incentives toward transparency. Therefore, it is expected that agribusiness companies are aware of both the content and presentation of socio-environmental information made available to stakeholders, since poor readability may compromise not only corporate image but also financial performance. In this sense, textual clarity is not merely a communicational attribute, but rather a strategic element aligned with corporate governance and organizational sustainability.

3 METHODOLOGICAL PROCEDURES

3.1 Sample and Data

This study adopts a documentary analysis approach focusing on annual financial reports, specifically explanatory notes (EN), management reports (MR), and sustainability reports. To compose the sample, the first step involved accessing the official B3 website (B3, 2024a) to identify publicly traded Brazilian companies associated with the agribusiness sector. This search was conducted on May 15, 2025, through the following path on the B3 website (B3, 2024a): Products and Services / Equities / Stocks / Listed Companies / Search by Sector. According to the classification of "Non-Cyclical Consumption" as the sector category, the following segments were selected: "Agriculture" and "Sugar and Alcohol" (subsector: Agriculture and Livestock) and "Dairy Products" and "Meat and Derivatives" (subsector: Processed Foods), after which the identified companies were recorded.

Following the identification of companies, annual financial reports were downloaded, specifically explanatory notes and management reports, totaling 204 and 208 reports, respectively, covering the fiscal years from 2015 to 2024, considering the expectation that reports related to the 2024 fiscal year would already be publicly available by May 2025. Each report was downloaded from the B3 website (B3, 2024b), within the area dedicated to structured reports published by listed companies. The period of analysis ended in 2024 because it represented the most recent period with available information as of May 2025.

The next stage involved collecting each company's sustainability reports through searches conducted on their institutional websites. These documents were primarily located within "Reports" sections or document disclosure areas. It was observed that there was no standardization in report titles, with a variety of terminologies identified, including *Sustainability Report*, *ESG Report*, *Environmental Responsibility Report*, *Green Bond Integrated Report*, and reports following the guidelines of the Global Reporting Initiative (GRI). By the date of data collection, 105 reports were available. For the purposes of this study, all nomenclatures were considered equivalent and included in the analysis due to the relevance of their content to the scope of the research.

Initially, the sample consisted of 27 companies, of which four were excluded because no reports were available on the B3 website. Therefore, the final sample comprised 23 companies. The sample included firms with available data for analysis, namely explanatory notes, management reports, and, where applicable, sustainability reports. Appendix A of this study presents the stock ticker codes of these companies as well as the number of reports per company. A total of 368 reports (ENs and MRs) and 131 sustainability reports were ultimately obtained for analysis, as detailed in Appendix A.

In this study, readability is adopted as the dependent variable. To assess readability with the support of Artificial Intelligence, excerpts related to environmental and social practices were selected from management reports, specifically those with the greatest impact on local communities and the environment. It should be noted that the use of Artificial Intelligence at this stage may introduce certain limitations, especially considering what recent studies (Malaquias & Hwang, 2025) have indicated regarding both the benefits and challenges associated with its use. Therefore, preliminary tests were conducted by comparing content extracted through Artificial Intelligence with manually extracted material. The results proved equivalent, which justified proceeding with the automated approach for report analysis. Additionally, the selected excerpts were compared against the existing literature and were found to provide evidence consistent with prior studies, reinforcing the importance of responsible resource use, social well-being, and environmental preservation.

Readability was assessed for each company and period based on the selected ESG-related excerpts. This evaluation was operationalized using the ALT tool (*Text Readability Analysis*) (Souza et al., 2025), which enables readability analysis of texts written in Portuguese (Moreno et al., 2022). The analysis performed through ALT is conducted using an online platform into which report text is inserted. The system then generates several textual statistics, including the Flesch Index. The following section presents the procedures employed, including the description of Artificial Intelligence support used to estimate the **FLESCH** variable.

Readability (FLESCH): The measurement of readability was conducted with the support of Artificial Intelligence. For this purpose, a prompt was developed to extract from each corporate report the excerpts related to the environmental and social dimensions, based on the dictionary provided by Huang et al. (2025). The dimensions associated with the environmental and social pillars in this dictionary comprise: E.1 General Environmental Management; E.2 Climate Change Mitigation and Adaptation; E.3 Ecological System and Biodiversity Protection; E.4 Resource Use and Circular Economy; E.5 Pollutant Emissions; E.6 Waste Management; S.1 Rural Revitalization and Social Contribution; S.2 Innovation and Technological Ethics; S.3 Employees; and S.4 Suppliers and Customers (Huang et al., 2025). As described in Appendix B, the content of each report was analyzed, and excerpts related to the environmental and social dimensions were extracted.

A Python script was developed in Google Colab and integrated with the Google Gemini model to automate the following procedure:

1. upload the report in PDF format;
2. submit the report content for analysis by Google Gemini, according to the prompt summarized in Appendix B;
3. save the response generated by Google Gemini in a .txt file and make it available for download.

Each .txt file containing the excerpts of interest from the respective report was then manually imported into the website legibilidade.com. After data processing on the platform, the resulting statistics were manually transferred to a spreadsheet, enabling the collection of readability measures, particularly the Flesch Index. As one of the potential explanatory variables, and in line with hypothesis H1 of this study, a managerial characteristic was considered: educational background in management-related fields. Through the analysis of the fre_cia_aberta_administrador_membro_conselho_fiscal_2025 file, collected from the public database of the Brazilian Securities and Exchange Commission (CVM) (CVM / Companies / Open Company Data / Publicly Traded Companies: Documents: Reference Form – FRE), it was possible to assess whether, in the respective year of analysis, the manager held an academic degree in any of the following areas: Business Administration, Accounting, Economics, or Production Engineering.

3.2 Control Variables

3.2.1 Firm Size

Firm size was selected in order to examine whether this characteristic affects the level and quality of disclosed information, given that firm size exerts a significant influence on the extent of information disclosure (Dihardjo & Hersugondo, 2023). This effect is more noticeable among small and medium-sized enterprises, which typically produce clearer reports, whereas larger firms, despite having greater resources, tend to generate more complex disclosures with lower readability.

Similarly, Goswami et al. (2023) suggest that firm size positively influences information readability, as large organizations adopt informational clarity as a strategy to mitigate conflicts between managers and shareholders. In contrast, Roiston and Harymawan (2020) concluded that there is a relationship between firm size and readability indicators, indicating that larger companies, due to their greater structural complexity, tend to produce less readable reports.

3.2.2 Audit Type (Big4)

Audits conducted by a Big Four firm indicate greater technical rigor and more readable reports, as evidenced by Zhang and Wang (2024), a finding also supported by Sun (2023). On the other hand, Weiyou et al. (2025) argue that audits performed by Big Four firms do not present a statistically significant effect in reducing discretionary accruals, demonstrating that merely hiring a large audit firm does not, by itself, guarantee a substantial improvement in disclosure quality. These findings reinforce the lack of consensus in the literature, as Mathath et al. (2025) found that Big Four audits do not significantly influence readability, since such firms concentrate primarily on financial information, whereas readability analysis in this context is applied to non-financial data.

3.2.3 Return on Assets (ROA)

According to Wahyuni et al. (2018), Return on Assets (ROA) does not influence the readability of annual reports, since firm performance is considered sufficient to demonstrate organizational conditions, thereby reducing the need for additional information that could affect textual clarity. In contrast, Aldoseri and Melegy (2023) argue that the readability of annual financial reports exhibits a significant and positive relationship with ROA, as organizations with higher profitability tend to demonstrate greater efficiency in communicating information, which is reflected in clearer and more accessible reports. Complementarily, Gu and Dodoo (2019) support this perspective by showing that Return on Assets positively affects annual report readability, suggesting that an average increase of 1% in a company's operational performance results in an increase of more than 100% in the clarity and comprehensibility of disclosed documents.

3.2.4 Leverage

According to Rahman et al. (2024), leverage exhibits a significant relationship with the readability of annual reports, such that higher leverage is associated with lower report readability. Similarly, Sun (2023) observes that companies with higher levels of leverage tend to produce more complex annual reports due to their easier access to external capital at lower costs. In contrast, the study conducted by Yan (2024) found no evidence that leverage exerts an influence on the readability of annual reports.

3.2.5 Firm Age

This variable was adopted based on the assumption that older firms have already established stakeholder loyalty, which could contribute to clearer and more objective reporting. In this context, Salehi et al. (2022) argue that firm age exerts a positive effect on audit report readability, as older organizations, due to their established market responsibility, tend to produce more readable reports. However, contrary findings are presented by Sun (2023), who demonstrates that the effect of firm age on annual report readability is negative, indicating that older companies produce annual reports with a higher degree of complexity. This result supports the arguments of Panta and Panta (2023), who likewise suggest that organizations with a longer operational history tend to present less readable reports.

To summarize the description of the study variables, Table 1 was developed and is presented below. It outlines the variables, their respective measurement approaches, and the main references that supported their selection in this study.

Table 1
Summary of the study variables

Variables	Abbreviation	Measure	References
Readability	Flesch	Flesch Index	Moreno et al. (2023); Smaili et al. (2023); Toerien e Du Toit (2024).
Management educational background	Management Education	Dummy variable assuming a value of 1 if the manager of firm ***i*** at time ***t*** has an educational background in a management-related field, and 0 otherwise.	Rajabalizadeh (2025); Zheng et al. (2025).
Firm age	FirmAge	Firm age measured from the year of incorporation.	Zhang e Wang (2024); Zheng et al. (2025).
Audit type	Audit	Dummy variable assuming a value of 1 if the company was audited by a Big Four firm in the respective year, and 0 otherwise.	Hu et al. (2024); Alduais et al. (2022); Zheng et al. (2025).
Firm size	Size	Natural logarithm of the company's Total Assets in the respective year.	Hu et al. (2024); Lin et al. (2023); Oliveira e Garcia (2024); Alduais et al. (2022).
Return on assets	ROA	Net Income / Total Assets	Zheng et al. (2025); Lin et al. (2023); Jaaffar et al. (2024).
Leverage	Liabilities/TA	Total Debt / Total Assets	Feng e Wu (2023); Zheng et al. (2025).

Source: Prepared by the authors.

3.2.6 Modelo Econométrico Formal

To examine the determinants of the readability of socio-environmental information disclosed by listed companies in the agribusiness sector, this study adopts a multiple linear regression model with panel data, as presented in Equation 1.

$$\text{Readability}_{it} = \beta_0 + \beta_1 * \text{MgmtEdu}_{it} + \beta_2 * \text{FirmAge}_{it} + \beta_3 * \text{Audit}_{it} + \beta_4 * \text{Size}_{it} + \beta_5 \text{ROA}_{it} + \beta_6 \text{Liab/TA}_{it} + \varepsilon_{it} \quad (1)$$

Based on Equation 1, the readability of socio-environmental reports is treated as the dependent variable. The model includes firm size, the presence of Big Four auditing, return on assets (ROA), financial leverage, firm age, and managerial educational background as explanatory variables. The use of panel data makes it possible to control for unobservable firm-specific effects and temporal variations, thereby reducing potential omitted variable bias. Thus, the econometric specification presented in Equation 1 enables the empirical testing of the proposed hypotheses by assessing the direction and statistical significance of the relationships under investigation.

The model was estimated using heteroskedasticity-robust standard errors. Following the application of the Hausman test (Fixed Effects versus Random Effects), the Breusch and Pagan Lagrange Multiplier (LM) test (Pooled Data versus Random Effects), and the Chow test (Pooled

Data versus Fixed Effects), the Fixed Effects panel model presented the most appropriate statistical fit indicators for hypothesis analysis. Additionally, the Variance Inflation Factor (VIF) statistic was assessed, with results remaining below 3 (maximum observed value: 2.73), suggesting the absence of concerns related to multicollinearity among the independent variables.

4 ANALYSIS AND DISCUSSION OF RESULTS

To examine the relationship between the potential determinants and readability, a panel dataset was constructed based on the collected information. The unit of analysis in this panel was firm × year. Since all companies had two reports (EN and MR), and some had three reports (EN, MR, and SR), the variables were aggregated by firm/period. Thus, readability came to be represented by the average score recorded by each company across its respective reports for a given year. Variables related to firm characteristics were already naturally organized by firm/period and therefore did not require any additional procedures. Table 2 presents the descriptive statistics of the panel dataset.

Table 2
Descriptive Statistics of the Study Variables

Variable	n	Mean	S>D.	Mín.	Max.
Flesch	151	34.057	6.154	19.600	52.400
MgmtEdu (dummy)	151	0.437	0.498	0.000	1.000
FirmAge	151	37.497	26.603	8.000	87.000
Audit (dummy)	151	0.662	0.475	0.000	1.000
Size (Ln)	151	22.581	2.060	19.028	25.655
ROA	151	5.399	5.773	-5.161	14.631
Liabilities/TA	151	65.361	32.493	23.793	147.973

Notes. All scalar variables were subjected to a winsorization procedure at the 5% level (2.5% at each tail). Management Education (dummy): dummy variable assigned a value of 1 if, in the respective year, the executive responsible for the company had an educational background in a management-related field, and 0 otherwise. Firm Age: firm age, measured in years and calculated annually. Audit (dummy): dummy variable assigned a value of 1 if the company was audited by a Big Four firm in the respective year, and 0 otherwise. Size (Ln): natural logarithm of the company's Total Assets in the respective year. ROA: return on assets reported by the company in the respective year. Liabilities/TA: ratio between total liabilities and total assets in the respective year.
Source: Prepared by the authors.

Regarding readability, the mean value observed was 34.057, classifying the reports as difficult to read, according to Moreno et al. (2023). The variation between the minimum and maximum values (min = 19.600 and max = 52.400) reveals different levels of textual comprehensibility. From a theoretical perspective, the low average readability reinforces the findings of Amiran and Jones (1982), according to which the complexity of economic and financial topics generates high informational density, making reading more difficult. Matricciani (2023) highlights the Flesch Index as an objective measure of such reading effort. The observed variation is consistent with Rahman et al. (2024), reflecting differences in organizational structure and communication capabilities across firms. The readability dilemma discussed by Abadi and Janani (2013) and Adhikari et al. (2023) reinforces the need for regulatory standardization, as advocated by Alodat et al. (2024), in order to ensure greater comparability and reliability of disclosed information.

It is important to emphasize the role of Artificial Intelligence resources, combined with the Python-based script, in supporting data collection and organization. These tools enabled the operationalization of textual analysis across a large set of financial reports, providing benefits in

terms of time efficiency and methodological standardization of analytical procedures, particularly when compared to individualized procedures conducted by different evaluators.

It was also observed that 66.2% of the companies were audited by a Big Four firm, which tends to favor greater transparency and compliance. However, as highlighted by Hongman and Qijia (2024), this choice alone does not guarantee better quality of disclosed information. Finally, the average debt ratio was found to be 65.36%, reaching as high as 147.97%, which, at this descriptive stage, suggests that more highly leveraged firms may seek to expand disclosure practices in order to reduce investors' perception of risk (Zhang & Wang, 2024; Sun, 2023).

Table 3 presents the results of the regression analysis (panel data, fixed effects), aimed at explaining the determinants of report readability within the sample. Two models were estimated. The first model considered only the managerial characteristic variable (educational background in management-related fields), whereas the second model included all independent variables.

Table 3

Regression Analysis Results: Readability

Variable	**Coef.**	**sig.**		**Coef.**	**sig.**	
MgmtEdu (dummy)	1,007	0,580		1.877	0.140	
FirmAge				-1.665	0.045	**
Audit (dummy)				5.392	0.000	***
Size (Ln)				2.629	0.140	
ROA				0.193	0.116	
Liabilities/TA				0.041	0.506	
Constant	33.617	0.000	***	24.007	0.339	
Year Dummy:	NO			YES		
r-quadr.: within	0.62%			22.48%		
between	20.16%			0.67%		
overall	0.75%			0.01%		
n	151			151		

Notes. Dependent variable: readability; Management Education (dummy): dummy variable assigned a value of 1 if, in the respective year, the executive responsible for the company had an educational background in a management-related field, and 0 otherwise; Firm Age: firm age, measured in years and calculated annually; Audit (dummy): dummy variable assigned a value of 1 if the company was audited by a Big Four firm in the respective year, and 0 otherwise; Size (Ln): natural logarithm of the company's Total Assets in the respective year; ROA: return on assets reported by the company in the respective year; Liabilities/TA: ratio between total liabilities and total assets in the respective year; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.
Source: Prepared by the authors.

Across both estimated models, managerial educational background in management-related fields was not found to be a factor significantly associated with the readability indicator. This result does not support the study hypothesis (H1), according to which management education could exert a significant effect on the readability level of ESG information. In light of Upper Echelons Theory, educational background in management did not emerge as an element capable of influencing the readability level of financial reports. The lack of statistical significance suggests that this proxy may fail to capture cognitive dimensions directly related to the communication effectively disclosed. This may result from several factors, such as the fact that the preparation of financial reports involves different individuals or departments, which may dilute the effect of individual managerial characteristics. Moreover, distinct personal characteristics of managers may carry different weights in shaping institutional decisions.

The results related to firm age reveal a negative coefficient that is statistically significant at the 5% level, indicating that older organizations tend to produce reports with lower readability.

This finding contradicts the study by Salehi et al. (2022), which associates organizational maturity with clearer reports due to accumulated market experience. On the other hand, the results align with evidence reported by Sun (2023) and Panta and Panta (2023), who also identified a negative relationship between firm age and report clarity, suggesting that more established companies tend to adopt more complex communication practices. Paradoxically, this scenario may damage investor perceptions, since mature companies are generally expected to exhibit greater transparency and informational quality.

Regarding audit quality, the results show positive and statistically significant coefficients at the 1% level in both models. This indicates that firms audited by a Big Four company tend to produce reports with higher readability, suggesting that the role of these firms not only enhances information credibility but also positively influences readability. This finding is consistent with the studies of Sun (2023) and Zhang and Wang (2024), which associate Big Four auditing with greater technical rigor and more readable reports.

However, the literature is not unanimous on this issue. Weiyou et al. (2025) argue that Big Four auditors do not have a statistically significant effect on reducing discretionary accruals, indicating that their engagement alone does not guarantee substantial improvements in report readability. Similarly, Mathath et al. (2025) found that Big Four auditing does not significantly influence readability, arguing that these firms primarily focus on financial information, whereas readability analysis frequently concerns non-financial data. Therefore, although the findings of this study support a positive relationship between Big Four auditing and readability, contradictory evidence in the literature indicates that this relationship remains inconclusive. Such divergence suggests that the impact of auditing on report clarity is mediated by other factors, making it a more complex and context-dependent phenomenon.

The results related to firm size did not reveal positive coefficients. This suggests that firm size is not necessarily associated with readability within the evaluated context. This finding differs from those of Goswami et al. (2023) and Xu et al. (2018), who attribute this relationship to large organizations' strategic use of clear communication as a mechanism for mitigating agency conflicts between managers and shareholders. Nevertheless, the literature presents divergent perspectives. The findings reported here contradict Dihardjo and Hersugondo (2023), who argue that firm size positively influences clarity, particularly among small and medium-sized firms, which tend to produce more objective reports, while larger firms generate more complex disclosures.

More directly, Enslin et al. (2025) concluded that the effect of firm size on readability is negative, arguing that the complexity inherent in large organizational structures results in less readable reports. Given these contradictory findings, it may be inferred that the relationship between firm size and report readability is not direct, but rather mediated by contextual and strategic factors. Therefore, larger organizational size does not linearly determine disclosure clarity, whose quality instead depends on governance priorities and communication practices specific to each organization.

Regarding ROA (Return on Assets), the results indicate positive coefficients, although without statistical significance. This suggests a tendency, albeit not statistically robust, for more profitable firms to produce reports with higher readability. This finding is consistent with Aldoseri and Melegy (2023), who identified a positive and significant relationship between ROA and annual report clarity, arguing that organizations with higher profitability tend to communicate information more efficiently. Complementarily, Gu and Dodoo (2021) reinforce this perspective by demonstrating that return on assets positively affects readability, to the extent that a 1% increase in operational performance is associated with more than a 100% improvement in document clarity. In contrast, Xu et al. (2018) argue that firms with higher stock returns, asset returns, and concentrated ownership structures are less likely to provide readable financial statements.

With respect to leverage (Liabilities/TA), the results indicate a positive coefficient, although without statistical significance. This suggests a weak tendency for more leveraged firms to produce slightly more readable reports. This finding conflicts with the established literature. Both Rahman et al. (2024) and Sun (2023) argue that higher leverage is associated with less readable and more complex reports, claiming that easier access to debt financing reduces the need for clear communication. On the other hand, the absence of a significant relationship in this study supports the conclusions of Yan (2024), who also found no statistical influence of leverage on readability. The lack of significance, combined with conflicting evidence in the literature, suggests that the effect of leverage on report clarity is, at minimum, inconsistent and likely mediated by other organizational variables.

Regarding practical implications, the results suggest that institutional and structural factors play a more relevant role in determining the readability of socio-environmental information when compared to strictly financial or performance-related variables. Overall, governance mechanisms and external monitoring appear to favor clearer and more understandable reports, whereas organizational characteristics associated with firm trajectory and maturity may negatively influence communication readability. These findings indicate that readability does not depend solely on a company's economic capacity, but primarily on institutional incentives and the quality of governance practices adopted.

From a practical standpoint, the findings indicate that audit quality plays a relevant role in the clarity of disclosed information, signaling to managers that hiring higher-reputation audit firms may contribute not only to credibility but also to the communication quality of ESG reports. For investors, the presence of a Big Four auditor may function as an indirect indicator of greater textual transparency and lower informational difficulty. For regulators, the results reinforce the importance of institutional mechanisms that encourage high standards of verification and oversight, given that an external governance indicator demonstrated an impact on readability.

5 FINAL CONSIDERATIONS

In a global scenario where sustainability is becoming increasingly relevant, corporate transparency emerges as a determining factor for corporate reputation and stakeholder trust. Considering this context, the objective of this research was to analyze the readability level of social and environmental information disclosed by companies in the agribusiness sector. The results indicate that Big Four auditing emerged as a positive and statistically significant determinant of readability. However, variables such as profitability (ROA) and leverage did not present statistically robust effects, reflecting the lack of consensus in the literature. The negative relationship between firm age and readability, in turn, aligns with recent findings (Sun, 2023; Panta & Panta, 2023), suggesting that the organizational complexity of established firms may compromise communication clarity.

This research reinforces its theoretical contribution by applying Upper Echelons Theory to the field of socio-environmental disclosure readability, extending its relevance beyond the context of traditional strategic decisions. The statistically non-significant effect observed for the managerial characteristic proxy based on educational background suggests that variables more directly associated with cognitive dimensions related to report publication may contribute to a better understanding of the readability of corporate texts. The study may also motivate further investigations into how organizational characteristics and governance mechanisms influence the textual clarity of corporate reports. Moreover, this research connects the disclosure literature with information quality in the agribusiness sector, a field characterized by substantial socio-environmental exposure.

In the context of public policy, these findings may support regulatory improvements aimed at enhancing the quality of ESG communication, particularly regarding the clarity and

comprehensibility of disclosed information. In this regard, minimum standards for textual readability in corporate reports may be established, potentially supporting initiatives promoted by regulatory bodies such as the Brazilian Securities and Exchange Commission (CVM) and the International Sustainability Standards Board (ISSB).

Overall, this study provides theoretical contributions by presenting evidence on how information asymmetry between managers and shareholders may be mitigated through the context of disclosure readability. In other words, companies play the role of disclosing information, and such disclosure may occur with different levels of readability. In turn, readability levels proved to vary across firms, particularly because organizational characteristics showed significant relationships with the Flesch Index. It is also important to note that textual readability, although relevant, does not fully encompass the informational quality embedded in reports, since highly readable reports may still contain superficial or strategically constructed content. This research innovates by analyzing the readability of both financial and non-financial reports, focusing exclusively on environmental and social parameters and employing a methodology supported by Artificial Intelligence.

This study presents some limitations. The first limitation concerns the exclusive focus on publicly traded companies listed on B3. Sustainability practices are also applicable to other organizations; therefore, analyzing reports or other documents from privately held companies may provide additional evidence regarding environmental disclosure. The proxy used for managerial characteristics, based on educational background, also represents a limitation, since other characteristics may play a relevant role in institutional decisions concerning published report content. Additionally, the use of Artificial Intelligence may introduce limitations related to the collected data. Future studies involving Artificial Intelligence are therefore encouraged to employ formal metrics for validating results, as well as reliability tests for generated outputs, which may help identify potential biases associated with the adopted tools. As suggestions for future research, it is proposed to: expand the sample to include agribusiness companies throughout Latin America; analyze disclosure practices in the mining sector, given its broader environmental impacts; investigate environmental disclosure using alternative methodological approaches, such as argumentative analysis or discourse analysis; and consider additional managerial characteristics in empirical tests.

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APPENDIX A

Research Sample

Stock Ticker	No. of Reports
ABEV3	30
AGRO3	29
AGXY3	16
BAUH4	21
BEEF3	26
BRFS3	30
CAML3	23
CTCA3	25
EGGY3	6
GRAO3	11
JALL3	19
JBSS3	27
JOPA4	20
LAND3	9
MDIA3	30
MNPR3	20
MRFG3	30
RAIZ4	28
SLCE3	27
SMTO3	20
SOJA3	12
TTEN3	10
VITT3	12

APPENDIX B

Summary of the Prompt Used with Google Gemini to Support Readability Assessment

Instructions (mode: semantic analysis of the attached PDF using category-based keywords)

The document analyzed below corresponds to a corporate report issued by a publicly traded Brazilian company listed on B3 (the Brazilian Stock Exchange). This material is publicly available.

{report upload}

You are an assistant specialized in document analysis. When processing the provided text, please perform the following tasks:

1. dentify all paragraphs in the report that are semantically or literally related to at least one keyword from each category listed at the end of this prompt.

2.Transcribe the complete narrative paragraphs (rather than lists, isolated phrases, or section titles) in which these keywords appear.

3.Notes:

3.1 Exercise caution with identical words used outside an ESG context. For example, the word “environment” in “economic environment” should not be considered, whereas “contributions to the environment” should be considered.
3.2 The search must be semantic: include paragraphs related to the theme of the keywords even if the exact term does not appear.
3.3 Always transcribe the complete paragraphs exactly as presented in the report, without modifications or additions.
3.4 If a paragraph contains more than one occurrence, including occurrences from different categories, transcribe that paragraph only once.
3.5 Present the results as a single continuous text, maintaining the original order in which the paragraphs appear in the report. It is not necessary to separate the transcription by category.
3.6 The extracted text must be clean and should not include labels or citation markers.

Keyword List (the environmental and social pillar keywords extracted from Huang, Zhang, Li, Mu, & Wang (2025) were inserted here and translated into Portuguese by the authors*).*

ACKNOWLEDGMENTS

This study was carried out with the support of the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), Brazil, Funding Code 001 (Bibiacha Angelina Nhagutou). Prof. Rodrigo F. Malaquias would like to acknowledge the support provided by the National Council for Scientific and Technological Development (CNPq) for the development of part of this research. Rodrigo F. Malaquias also acknowledges the support granted by the Minas Gerais Research Foundation (FAPEMIG) for the execution of part of this study (Universal Demand Project, 2022, APQ-02071-22, Call Notice 001/2022).

CONFLICT OF INTERESTS.

The authors declare no conflict of interests.

DATA AVAILABILITY

The dataset supporting the findings of this study is not publicly available.

AUTHOR CONTRIBUTIONS

Roles	1st author	2nd author
Conceptualization	♦	
Data Curation	♦	
Formal Analysis	♦	♦
Funding Acquisition	♦	♦
Investigation	♦	
Methodology	♦	♦
Project Administration	♦	♦
Resources	♦	♦
Software	♦	♦
Supervision		♦
Validation	♦	♦
Visualization	♦	♦
Writing – Original Draft	♦	
Writing – Review and Editing	♦	♦