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Evaluating the disclosure of impacts, risks, and opportunities in sustainability reports published by Brazilian companies: a multicriteria decision analysis

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ABSTRACT

This study evaluates the sustainability reporting practices of Brazilian companies, focusing on the disclosure of impacts, risks, and opportunities in alignment with 12 Global Reporting Initiative (GRI) recommendations. Data were collected from 27 experts with extensive academic and professional experience in corporate sustainability and analyzed using the Fuzzy TOPSIS Class method. The findings reveal gaps in transparency and stakeholder engagement, with 83% of recommendations being followed in an unstructured manner and 17% being not followed at all, particularly considering the disclosure of economic, environmental, and social impacts, as well as stakeholder expectations and interests. These deficiencies pose risks such as reputational damage, reduced investor confidence, and non-compliance with regulatory standards. By addressing these gaps, companies can enhance stakeholder trust, improve regulatory alignment, and position themselves as leaders in sustainability. The study provides actionable insights for companies to enhance reporting quality and for policymakers to establish more robust guidelines to improve accountability and transparency in sustainability disclosures.

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1. Introduction

Although a relatively new term, the concept of sustainable development has been present in academic writings for several centuries and in ancient indigenous cultures (Agbedahin, 2019). In August 1987, the World Commission on Environment and Development (WCDE), through its report titled 'Our Common Future,' popularized the concept of sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (United Nations, 1987). However, by the year 2000, various paths toward sustainability faced significant challenges in achieving widespread success, as highlighted by Abeysekera (2022), due to structural, economic, and societal barriers. The focus on sustainability gained momentum as the United Nations (UN)

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intensified discussions and set goals aimed at eliminating inequalities and improving the quality of life among nations (Hamad et al., 2023).

The culmination of these efforts materialized in the form of the Sustainable Development Goals (SDGs) (Mosgaard & Kristensen, 2023), considered the broadest agreement on environmental and social challenges (Ordonez-Ponce et al., 2021). Comprising 17 objectives and 169 targets to be achieved between 2016 and 2030, the SDGs aim to combat climate change, eradicate poverty, reduce inequalities, and achieve sustainable development by 2030. They stand as a global reference for sustainability (Folqué et al., 2023; Hamad et al., 2023). Responsibility for the realization of the SDGs falls on all sectors and countries, including public organizations, civil society, and the private sector (Ordonez-Ponce et al., 2021; Rampasso et al., 2021). However, transforming business attitudes towards new sustainable practices, technologies, and business models poses a considerable challenge to implementing the SDG Agenda (Rosati & Faria, 2019).

Organizations play a significant role in advancing this agenda globally by providing innovative solutions to the challenges of sustainable development. This involves integrating the SDGs into their strategies and operations (Martins et al., 2020; Rosati & Faria, 2019). In doing so, they contribute to the collective effort of addressing global sustainable development challenges and promoting a more sustainable future. Kraus et al. (2020) note that organizations are increasingly under pressure from stakeholders to explain their environmental and social approaches, requiring successful companies to align their performance with the public expectations. To communicate their sustainable actions to stakeholders, companies have been publishing sustainability reports within specific periods (Arianpoor et al., 2023; Haladu & Bin-Nashwan, 2021; Jamil et al., 2021).

While some corporate reports may focus more on disclosing environmental or social issues, the triple-bottom-line approach remains crucial. This approach, through which organizations seek a better balance among economic, social, and environmental objectives, is widely acknowledged (Sandberg & Holmlund, 2015; Sepasi et al., 2019; Tsalis et al., 2020). It is important to emphasize that society increasingly calls for investors to incorporate environmental, governance, and social data into their investment processes (Ching & Gerab, 2017; Yu et al., 2020). Thus, sustainability reports serve as a vital tool for organizations to communicate their activities to stakeholders (Aluchna et al., 2023; Chowdhury et al., 2021; Sawani et al., 2010).

Concerning sustainability reports, there are significant initiatives aiming to guide organizations on how to provide detailed information about their sustainable actions to society. Notable examples include the Global Reporting Initiative (GRI) and Integrated Reporting. However, these initiatives are voluntary, and it is up to companies to fully comply with the recommendations made. Boiral et al. (2019) and Yu et al. (2020) argue that the lack of auditing for most sustainability reports increases the likelihood of companies engaging in 'greenwashing.' In Brazil, this likelihood is further exacerbated by cultural and economic factors. In regions where public awareness of sustainability issues is limited, there is less societal pressure on companies to ensure the credibility of their sustainability claims. Additionally, the economic environment, characterized by a strong focus on short-term profitability in some industries, often incentivizes companies to present an overly favorable image of their sustainability performance without fully committing to meaningful actions. These factors, combined with the lack of robust monitoring mechanisms, increase the risk of greenwashing in Brazilian corporate sustainability reporting.

In this context, scholars have advocated for sustainability reports to be verified by accounting firms and consultancies to provide greater credibility to society in the information provided (Ching & Gerab, 2017; Sandberg & Holmlund, 2015). Academic literature widely criticizes the reliability and credibility of information presented in sustainability reports by most companies (Cazeri et al., 2021; Emel et al., 2012). While there are excellent companies whose actions in Corporate Social Responsibility (CSR) deserve recognition, as discussed by Anholon et al. (2016), there is still much room for improvement in terms of the quality of the information presented.

Brazil presents a unique and critical context for sustainability reporting. As one of the world's largest emerging economies, it is home to vast natural resources and a complex economic landscape that includes both multinational corporations and smaller domestic enterprises. This diversity creates challenges in aligning corporate practices with international sustainability standards. Additionally, Brazil faces significant environmental pressures, such as deforestation in the Amazon, water scarcity or floods, and

other climate change related impacts, which amplify the need for transparent and credible sustainability disclosures. This can support other emerging economies with similar issues, serving as a reference case.

However, the voluntary nature of GRI adherence and the lack of enforcement mechanisms have led to inconsistencies in the quality and depth of sustainability disclosures in Brazil. Many companies struggle to transparently report their impacts, risks, and opportunities, creating gaps in accountability and stakeholder trust. Hence, this study seeks to aid in overcoming these challenges by addressing the following problem: Hence, this study seeks to answer the following question: How effectively do Brazilian companies disclose impacts, risks, and opportunities in their sustainability reports, and what are the key areas that need improvement to enhance transparency and stakeholder trust? This research does not analyze specific sustainability reports but instead relies on evaluations provided by 27 experts. The experts provided an overview of the degree of adherence by Brazilian companies to the 12 GRI recommendations, offering an exploratory overview of sustainability reporting practices in Brazil.

Therefore, the objective of this research is to evaluate the quality of sustainability reporting practices among Brazilian companies, focusing on how well these companies adhere to the 12 recommendations provided by the Global Reporting Initiative (GRI). The study focuses on identifying critical gaps in transparency, areas of potential reputational risk, and improvement opportunities that can guide corporate managers and policymakers in enhancing the quality and reliability of sustainability disclosures. By analyzing these reports, the study provides a comprehensive assessment of the current state of sustainability reporting in Brazil and its impact on stakeholder engagement, particularly in terms of investor confidence and regulatory compliance.

Evaluating the disclosure of impacts, risks, and opportunities in sustainability reports is paramount for both companies and society. Failure to clearly disclose these elements can lead to significant risks, such as reputational damage and decreased investor confidence, as well as missed opportunities for improving sustainability practices. This study focuses on how Brazilian companies report on these key areas, evaluating the quality of their disclosures through the lens of the 12 GRI recommendations. For companies, a transparent and comprehensive disclosure not only enhances their credibility but also facilitates informed decision-making by stakeholders, fostering trust and loyalty (Ching & Gerab, 2017; Jamil et al., 2021). It enables companies to align their sustainability practices with the expectations of increasingly conscientious consumers and investors, thereby contributing to long-term viability and competitiveness (Arianpoor et al., 2023).

Moreover, a robust evaluation process helps companies identify areas for improvement, promoting continuous progress in sustainable practices (Haladu & Bin-Nashwan, 2021). For society, these evaluations provide valuable insights into the environmental, social, and governance aspects of corporate operations, empowering stakeholders to make informed choices, advocate for responsible business practices, and drive positive societal and environmental outcomes (Sandberg & Holmlund, 2015; Sawani et al., 2010; Sepasi et al., 2019). In essence, the evaluation of sustainability reports serves as a catalyst for a more sustainable and ethical business landscape, benefiting both corporate entities and the broader community.

In the era of growing environmental and social concerns, corporate sustainability reports play a crucial role in communicating a company's performance and accountability. Yet, many corporate sustainability reports lack the depth required to meet stakeholders' expectations, and the prevalence of 'greenwashing' continues to undermine trust in corporate claims (Anholon et al., 2016; Mendes et al., 2024). This study contributes to the literature by providing an in-depth analysis of Brazilian companies' adherence to GRI standards, a widely recognized framework for sustainability reporting, and highlights opportunities for companies to enhance their transparency and long-term sustainability.

Moreover, the novel contribution of this study lies in its application of the Fuzzy TOPSIS Class method to evaluate sustainability reporting practices in Brazil, a context where adherence to international standards like the GRI remains voluntary and inconsistent. By focusing on expert-driven assessments and integrating a robust methodological framework, the study provides actionable insights into the critical gaps in transparency and stakeholder engagement, offering a pathway for companies to enhance their sustainability practices. This approach not only advances the academic discourse on sustainability reporting but also contributes practical recommendations for improving accountability and alignment with global standards.

In addition to this introduction, the article comprises four additional sections. Section 2 provides the theoretical framework, focusing primarily on aspects related to corporate sustainability, sustainability reports, and the disclosure of impacts, risks, and opportunities by companies. Section 3 outlines the methodological procedures that led to the results, ensuring a comprehensive detailing of the conducted activities. Section 4 presents the results and discussions, followed by the conclusion and final considerations.

2. Theoretical background

2.1. Corporate social responsibility and competitive strategy

There is a growing commitment among these organizations to actively engage in and promote sustainability and environmental and social responsibility within the realm of CSR (Singh & Misra, 2021). CSR constitutes an organizational strategy aimed at mitigating adverse impacts on the external environment to preserve cultural, economic, and social aspects of the communities where a company operates (Abbas, 2020; Islam et al., 2021; Xu, 2023).

CSR strategies have gained increasing attention in business models (Blinova et al., 2023; Pazienza et al., 2022). It is becoming increasingly evident that world-class management involves integrating sustainable development principles into organizational structures (Asif et al., 2013; Cazeri et al., 2018; Pazienza et al., 2022). Despite the ISO 26000 advocating the integration of all CSR practices into business strategies, this integration does not always occur (Cazeri et al., 2018).

Over the past decade, the significance of CSR for the sustainable development of our planet has led to a surge in academic publications on the subject (Ye et al., 2020). The number of specialized journals highlighting the benefits of corporate sustainability for business managers has also increased (Meuer et al., 2020). As noted by Abbas (2020) and Islam et al. (2021), initiatives related to CSR practices have become a competitive strategy for companies to enhance profits, employee satisfaction, customer loyalty, reputation, and positive brand attitudes.

Underlining the importance of CSR for sustainable development and aiming to assist companies in this regard, numerous entities and organizations provide knowledge, agreements, and standards: The United Nations Global Compact, the Organization for Economic Cooperation and Development (OECD) directory for multinational enterprises, the International Organization for Standardization (ISO) standards for environmental and social management, the Sullivan Principles (Delchet-Cochet & Vo, 2013).

The Global Reporting Initiative (GRI), and Integrated Reporting frameworks focus on disseminating guidelines for sustainability reporting, crucial instruments for sustainability governance (IIRC, 2021; Cazeri et al., 2021). Sustainability reports respond to the informational demands of specific stakeholder groups: investors rely on these reports to assess financial risks and opportunities related to environmental, social, and governance (ESG) factors, enabling more informed investment decisions; customers seek transparency to ensure that the companies they support align with their values, particularly in areas such as environmental sustainability and social responsibility. employees look for evidence of a company's commitment to sustainability as part of evaluating its organizational culture and long-term vision; and regulatory bodies use these reports to monitor compliance with national and international sustainability standards (Manetti & Toccafondi, 2012; Romero et al., 2019). By addressing these varied demands, sustainability reports serve as critical tools for fostering accountability and building trust across diverse stakeholder groups (Romero et al., 2019).

2.2. Sustainability reporting and GRI standards

The demand for sustainability reports has intensified due to the increasing public awareness of social and environmental issues (Argento et al., 2019). A growing number of companies regularly publish sustainability reports in response to the mounting pressure to provide stakeholders with relevant information about their CSR (Pasko et al., 2021). Stakeholder engagement can enhance the credibility and communication of sustainability reports (Dewi et al., 2023). Managing stakeholders involves meeting their

expectations, encouraging their involvement in decision-making, and establishing a model of mutual responsibility with the organization (Baffo et al., 2023; Pasko et al., 2021).

According to Boiral et al. (2019) and Rosati and Faria (2019), stakeholders can gain a deeper understanding of the actions undertaken by a particular organization through sustainability reports. These authors also argued that the enhancement of reputation among stakeholders and the reduction of information asymmetries are considered driving factors for sustainability reporting (Blasiak et al., 2021; Boiral et al., 2019; Rosati & Faria, 2019). Marimon et al. (2012) argue that adhering to guidelines for sustainability reporting leads to greater standardization and harmonization, facilitating societal comparisons among companies.

Founded in 1997 in response to the Exxon Valdez oil spill, the Global Reporting Initiative (GRI) is an independent international organization whose standard is widely used for sustainability reporting (Mougenot & Doussoulin, 2023). The GRI's reference model stands out as the best option, grounded in the triple bottom line principles encompassing environmental, economic, and social dimensions (Boiral et al., 2019; de Villiers & Sharma, 2020; Marimon et al., 2012). As an independent international organization, the GRI assists companies, governments, and organizations in understanding and communicating their impacts (de Villiers & Sharma, 2020). It has become the benchmark for sustainability reporting, with its framework providing reporting principles and disclosure standards used by over 90% of the world's top 250 companies (Boiral et al., 2019; de Villiers & Sharma, 2020).

To ensure the usefulness and reliability of information in sustainability reports for stakeholders, the GRI proposes following two sets of principles, one related to content and the other to quality (Boiral et al., 2019). The content-related principle determines the indicators and themes that organizations should report (Marimon et al., 2012). Regarding quality, sustainability reports should be based on the presentation and transparency of disclosed information: these details should not focus solely on positive aspects but should be comparable over time and among companies, clear, reliable, detailed, regular, and up to date (Boiral et al., 2019; Marimon et al., 2012).

In line with this, the 2021 version of the GRI standard introduces the principle of verifiability, which aims to enable the analysis of the quality of information provided by the organization through its collection, analysis, recording, and compilation processes (GRI, 2023). The GRI 2021 standard also provides organizations with guidelines for applying this principle, ensuring that information can be examined for adherence to reporting principles and its accuracy (GRI, 2023).

Within its comprehensive structure, the GRI standard has subdivisions, notably Section 200 focusing on economic aspects, Section 300 on environmental aspects, and Section 400 on social aspects (Cazeri et al., 2021). The GRI's G4 Sustainability Reporting Guidelines (2013) emphasize that organizations should present two precise narrative sections about their impacts, risks, and opportunities (GRI, 2013). In the first section, organizations should focus on their primary sustainability impacts and their effects on stakeholders, including compliance with internationally recognized standards and rights stipulated in national legislation (GRI, 2013). In the second section, organizations should concentrate on sustainability impacts, trends, risks, and opportunities concerning their financial performance and long-term outlook (GRI, 2013).

For the purposes of this study, GRI 102-15, which presents 12 broad recommendations for companies to disclose their key impacts, risks, and opportunities (GRI, 2016), is particularly highlighted, as outlined in Table 1.

A critical challenge in sustainability reporting is the risk of misrepresentation, commonly referred to as greenwashing: it occurs when companies selectively report favorable information or exaggerate their sustainability efforts while omitting critical aspects of their environmental or social impacts, which can mislead stakeholders, undermine trust, and expose companies to reputational damage and regulatory scrutiny (Mendes et al., 2024). The lack of mandatory auditing for most sustainability reports exacerbates this issue, as it allows companies to present unverified claims (Boiral et al., 2019; Yu et al., 2020).

The 12 GRI recommendations provide a globally recognized framework for corporate sustainability reporting, focusing on transparency, stakeholder engagement, and accountability (GRI, 2016). These principles guide companies in disclosing their environmental, social, and governance (ESG) impacts, making them pertinent for this study (Cazeri et al., 2021). In the context of Brazilian companies, where sustainability reporting often lacks rigor and depth, adherence to these GRI principles becomes essential to assess the quality and comprehensiveness of their disclosures (Cazeri et al., 2018).

Table 1. GRI recommendations for companies when disclosing their key impacts, risks, and opportunities.

Code	Item (GRI)	Description
IT1	2.2.1	A description of the organization's significant economic, environmental, and social impacts, as well as the challenges and opportunities related to these impacts. This includes effects on stakeholders and their rights outlined in national legislation and internationally recognized standards (GRI, 2016, p. 15).
IT2	2.2.2	The range of reasonable expectations and interests of the organization's stakeholders (GRI, 2016, p. 15).
IT3	2.2.3	An explanation of the approach adopted to prioritize these challenges and opportunities (GRI, 2016, p. 15).
IT4	2.2.4	Key conclusions on the progress in addressing these topics and the performance achieved during the reporting period, including an evaluation of the reasons for underperformance or overperformance (GRI, 2016, p. 15).
IT5	2.2.5	A description of the main processes established to address issues related to performance and relevant changes (GRI, 2016, p. 15).
IT6	2.2.6	The impact of sustainability trends, risks, and opportunities on the organization's long-term outlook and financial performance (GRI, 2016, p. 15).
IT7	2.2.7	Relevant information, or information that may become relevant in the future, for financial stakeholders (GRI, 2016, p. 15).
IT8	2.2.8	A description of the most significant risks and opportunities for the organization arising from sustainability trends (GRI, 2016, p. 15).
IT9	2.2.9	Prioritization of key economic, environmental, and social topics as risks and opportunities, according to their long-term relevance to organizational strategy, competitive advantage, qualitative financial value drivers, and, if possible, quantitative ones (GRI, 2016, p. 15).
IT10	2.2.10	Table(s) with a summary of goals, performance against goals, and lessons learned during the reporting period (GRI, 2016, p. 15).
IT11	2.2.11	Table(s) with a summary of goals for the next reporting period and medium-term objectives and goals (i.e. for the next three to five years) related to key risks and opportunities (GRI, 2016, p. 15).
IT12	2.2.12	A description of the governance mechanisms adopted specifically to manage these risks and opportunities and to identify other potential risks and opportunities (GRI, 2016, p. 15).

Source: Elaborated by the authors based on GRI (2016).

The research question of this study is directly linked to the evaluation of these 12 GRI recommendations. By assessing the alignment of corporate disclosures with these principles, this study seeks to determine, in the big picture, whether Brazilian companies are meeting international standards and identify the areas where they fall short. Moreover, while transparency is a critical aspect of this evaluation, the study also examines whether disclosures are comprehensive, accurate, and aligned with stakeholders' informational needs. By identifying areas for improvement, the research provides insights not only into transparency but also into the overall quality and relevance of sustainability reporting practices.

Hence, in addition to GRI (2016), other two main constructs compose the theoretical basis of this study. Stakeholder theory emphasizes the importance of organizations addressing the needs and expectations of various stakeholder groups, including investors, customers, employees, and regulatory bodies (Freeman, 2010). Sustainability reporting aligns closely with this theory, as it serves as a critical communication tool to inform stakeholders about a company's environmental, social, and governance (ESG) practices. By adhering to GRI recommendations, organizations demonstrate their commitment to transparency and accountability, thereby fostering trust and long-term relationships with stakeholders. Legitimacy theory posits that organizations seek to align their operations with societal norms and expectations to maintain their social license to operate (Suchman, 1995). Sustainability reporting, guided by frameworks like the GRI, is a means for companies to demonstrate compliance with societal values and mitigate risks associated with perceptions of greenwashing or non-compliance. In the Brazilian context, where regulatory frameworks for sustainability reporting remain underdeveloped, adherence to international standards such as the GRI becomes an essential strategy for companies to establish legitimacy and competitive advantage.

3. Material and methods

This research was conducted in seven stages, as illustrated in Figure 1. To analyze the effectiveness of Brazilian companies' sustainability reporting practices, we employ the Fuzzy TOPSIS Class method, a multicriteria decision making tool.

TOPSIS, which stands for Technique for Order Preference by Similarity to Ideal Solution, is widely used to rank and select among competing alternatives in situations where multiple criteria must be considered. It is a widely applied technique to solve multicriteria decision making (MCDM) problems that aim to rank the alternatives and select the best solution based on criteria and using a simple and intuitive algorithm (Yadav et al., 2018). The development of the TOPSIS algorithm is based on the idea to achieve

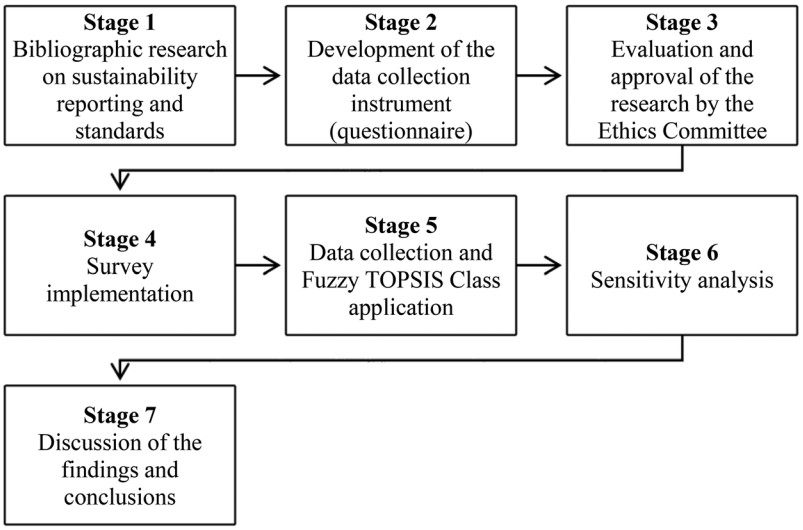

Figure 1. Research stages. *Source:* Authors' own creation.

a solution that is both as close as possible to the positive ideal solution and as far as possible from the negative ideal solution (Shukla et al., 2017). Since its proposition by Hwang and Yoon (1981), the TOPSIS technique has become one of the most used MCDM methods with the development of different extension proposals (Çelikbilek & Tüysüz, 2020).

The choice of the TOPSIS method as a basis, considering its classification variant, is well-suited to this study due to the complexity and multidimensional nature of sustainability reporting. Sustainability reports involve various criteria, including transparency, compliance with regulations, and stakeholder engagement, which must be evaluated simultaneously. Traditional evaluation methods are often insufficient to capture the nuanced differences between sustainability practices, especially when dealing with subjective expert assessments.

The Fuzzy extension of TOPSIS is particularly appropriate because it allows for the incorporation of uncertainty and imprecision, common in expert opinions (Chen et al., 2020). In addition, the decision to use the Fuzzy TOPSIS Class (FTC) method was driven by the need to address the inherent subjectivity and variability in expert evaluations of sustainability reporting practices. FTC is particularly suitable for this study as it integrates linguistic assessments with fuzzy logic, enabling a more nuanced and reliable classification of adherence to GRI recommendations (Ferreira et al., 2018). Unlike traditional scoring methods, FTC accommodates uncertainty in expert judgments, which is critical when evaluating complex and qualitative dimensions such as stakeholder engagement (IT2) and impact disclosures (IT1) (Feitosa et al., 2021). This methodological choice ensures robustness in the results by reducing the potential bias and variability associated with subjective evaluations (Ferreira et al., 2018). Furthermore, the sensitivity analysis conducted in two distinct scenarios reinforces the reliability of the findings by demonstrating the stability of classifications under different assumptions about expert inferential capacity (Feitosa et al., 2021). By combining expert-driven assessments with the FTC methodology, the study bridges the gap between theoretical guidelines (GRI recommendations) and their practical application in corporate sustainability reports.

In this study, 27 experts evaluated 12 Global Reporting Initiative (GRI) recommendations using linguistic terms. The selection of the 27 experts was based on strict predefined criteria to ensure their inferential capacity and the reliability of their evaluations. Specifically, the experts were required to have a minimum of five years of academic or professional experience in sustainability reporting, corporate sustainability, or related fields, as well as demonstrated familiarity with the GRI framework. Furthermore, their active involvement in sustainability practices within the Brazilian context, either through research or professional activities, ensured that their input was both contextually relevant and informed. These criteria ensured that the experts' judgments were based on robust knowledge and practical experience, which supports the reliability of their input.

No independent validation of individual responses was conducted since the study aimed for the general picture. Hence, potential individual biases in expert judgments were addressed using fuzzy set theory and computing with words (Zadeh, 1996). This approach mathematically computes subjectivity by converting qualitative evaluations into fuzzy numbers, which are then aggregated to produce a balanced and comprehensive assessment (Chen et al., 2020).

It is important to note that the 27 experts in this study do not represent the entire population of professionals in Brazilian sustainability reporting. They were selected based on their expertise and relevance to the country's context, ensuring the evaluation reflects informed and contextually grounded judgments rather than serving as a direct representation of the companies themselves. The study's exploratory nature justifies this approach, as its primary goal is to establish an initial understanding of the alignment of sustainability reports with GRI recommendations and to identify key areas for improvement, as these practices are still in their early stages in Brazil.

Additionally, the use of fuzzy linguistic representation (Zadeh, 1996) aligns with the sample size, as this methodological approach captures expert knowledge with depth, mitigating the need for larger sample sizes. Unlike conventional statistical methods, fuzzy linguistic studies rely on a different way of processing data, where the focus is on aggregating qualitative and subjective judgments into meaningful insights (Feitosa et al., 2021; Zadeh, 1996). While the sample size of 27 may appear limited in conventional statistical terms, studies employing fuzzy methodologies often use smaller sample sizes (Tietz Cazeri et al., 2024). This methodological choice allows for nuanced insights into GRI adherence, particularly in a field where sustainability reporting practices are still nascent.

Hence, this study methodologically contributes to the existing body of knowledge by providing a systematical approach for assessing adherence to GRI recommendations. It offers a foundation for future assessments with larger or more focused samples. By choosing this expert-driven evaluation, the study establishes an initial benchmark for understanding the shades of sustainability reporting practices in Brazil.

This research was conducted in accordance with the ethical guidelines for research conduct of the State University of Campinas (Brazil) and approved by the Research Ethics Committee of this university under the Certificate of Ethical Appreciation number 60504922.0.0000.5404. The informed consent was presented in a written form and obtained from all participants.

In Stage 1, a systematic literature review was conducted to establish the theoretical basis of the study and to clarify the research gap. This stage also involved the analysis of sustainability reporting standards and documents on the topics produced by respected institutions in the field of CSR and sustainability reporting. This was fundamental to establishing a solid background for the subsequent stages. This was followed by a deeper examination of the GRI standard, particularly the GRI 102-15, which provides 12 recommendations for presenting impacts, risks, and opportunities, which served as the basis for formulating the 12 recommendations used as a structure for data collection and analysis (Table 1).

Thus, the 12 recommendations from GRI 102-15 served as the basis for structuring the research questionnaire (Stage 2). The first part of the questionnaire was dedicated to characterizing the sample (e.g. background or field experience), while the second part focused on evaluating each of the GRI recommendations.

Fuzzy set theory provides a robust framework for encapsulating subjective evaluations inherent in decision-making processes, as suggested by Zanon and Carpinetti (2021). Linguistic variables, employed to qualitatively express these evaluations, undergo a transformation into quantitative representations through fuzzy sets within a discourse universe, utilizing pertinence functions—a methodology aligned with the principles of computing with words, as articulated by Klir and Yuan (1995). This approach accounts for subjectivity by recognizing the possibility of a single element belonging to multiple fuzzy sets simultaneously, a fundamental outcome of the parameterization of pertinence functions, as elucidated by Zadeh (1978). By integrating linguistic variables and fuzzy numbers, decision-makers can navigate through complex decision spaces while addressing inherent uncertainties and ambiguities.

For a given universe $X \to [0,1]$, a fuzzy set $\tilde{A}$ can be defined as: $\tilde{A} = \{x, \mu_A(x)\}, x \in X$, in which $\mu_A(x)$ is the membership degree function of the element x in $\tilde{A}$. The function $\mu_A(x)$ takes values in the interval $[0,1]$, where if $\mu_A(x) = 1$, x belongs totally to the fuzzy set $\tilde{A}$; otherwise, if $\mu_A(x) = 0$, then x does not

belong to the fuzzy set $\tilde{A}$. Besides that, if $0 < \mu_A(x) < 1$, then x partially belongs to the fuzzy set $\tilde{A}$ (Dubois, 1980). A fuzzy number can be defined as a fuzzy set with the membership function that satisfies the conditions of normality ($\sup \tilde{A}[x]_x \in X = 1$) and convexity ($\tilde{A}[\lambda x_1 + (1-\lambda)x_2 \geq \min[A(x_1), A(x_2)]] \forall x_1, x_2 \in X$ and $\forall \lambda \in [0,1]$) (Zimmermann, 2010).

Fuzzy sets and, therefore, fuzzy numbers, are described by their respective membership functions, which associate every $x_i \in X$ with its corresponding $\mu_A(x)$. Among the most used, is the triangular kind. So let l, m, and u be real numbers. A triangular fuzzy number is usually represented as $\tilde{A} = (l, m, u)$.

Table 2 presents the scale containing linguistic terms used in the questionnaire, along with the representation of each term in the form of triangular fuzzy numbers (TFN). According to Chen et al. (2020), the use of linguistic terms for data collection is more conducive and realistic, capturing people's perceptions more effectively. The scale in Table 2 is constructed based on the computing with words approach and comes from several applications reported on the fuzzy set theory related literature (Zadeh, 1996; Zanon et al., 2024).

Once the main aspects of the study were defined and the research instrument was structured, the research Project was submitted to the university's Research Ethics Committee (Stage 3) and received approval (certificate number CAAE 60504922.0.0000.5404).

In Stage 4, data collection was initiated through a survey, following the recommendations of Forza (2002). Data were collected using the Google Forms platform. The study involved 27 experts with extensive academic and professional experience in the fields of corporate sustainability and sustainability reporting. These experts were chosen based on criteria such as years of experience, publications in sustainability reporting, and roles in corporate sustainability initiatives.

The questionnaire was structured in two main parts: the first part collected information on the experts' backgrounds, such as their years of experience, professional roles, and familiarity with sustainability reporting practices; second part focused on the 12 GRI recommendations, asking the experts to evaluate the degree of adherence by Brazilian companies to each recommendation. A linguistic scale was used, presented in the first column of Table 2.

Since expert judgments are inherently subjective and often imprecise, the qualitative responses were converted into triangular fuzzy numbers (TFNs) to better represent the uncertainty and variability in the assessments. The fuzzy numbers provided a mathematical way to process the linguistic data, with each response mapped to a specific range that captures the uncertainty around the expert's evaluation. For example: 'Most companies do not follow this recommendation' might be represented by the TFN (0, 0, 2.5), indicating a very low degree of compliance.

The responses from the 27 experts for each GRI recommendation were then compiled into a fuzzy decision matrix, where the rows represent each GRI recommendation (12 in total), and the columns represent each expert's evaluation. This decision matrix formed the core dataset used in the analysis. The use of fuzzy numbers allowed for the integration of all expert opinions into a single dataset, reflecting not only the individual assessments but also the degree of uncertainty associated with each response.

The evaluation focused on assessing Brazilian companies' sustainability disclosures in terms of their adherence to the 12 GRI recommendations. This assessment aimed to determine not only the level of compliance but also the extent to which companies effectively communicate impacts, risks, and opportunities in alignment with the GRI framework. The experts' evaluations provide a comprehensive understanding of how well these companies meet global standards, while highlighting areas for improvement to enhance transparency and stakeholder engagement.

Table 2. Scale with linguistic terms used in the questionnaire and its TFN representation.

	TFN		
Linguistic terms	***l***	***m***	***u***
Most companies do not follow the recommendation in question	0	0	2.5
Most companies follow the recommendation in question in a very superficial manner	0	2.5	5
Most companies follow the recommendation in question in a simple manner	2.5	5	7.5
Most companies follow the recommendation in question in a structured way, but it is still possible to identify some deficiencies	5	7.5	10
Most companies follow the recommendation in question in a well-structured manner	7.5	10	10

Source: Authors' own creation.

In Stage 5, these collected data were analyzed using the Fuzzy TOPSIS Class (FTC), an extension of the TOPSIS approach proposed by Ferreira et al. (2018). FTC falls under the category of MCDM methods, which aims to assist a decision-maker in making the best choice among many possible options, considering a multitude of criteria and enabling a more efficient, explicit, and rational decision-making process (Velmurugan et al., 2022). Widely applied to improve decision quality, MCDM can be enhanced by the joint use of fuzzy numbers in various areas such as engineering, science, and management and technology (Bobel et al., 2022; dos Santos et al., 2024). Feitosa et al., 2021; Pompilio et al., 2023; Wątróbski et al., 2019;

The TOPSIS method was developed by Hwang and Yoon (1981) and is considered one of the most popular MCDM techniques due to its simplicity. It is widely used in multicriteria problem resolutions and applied to practical issues (Palczewski & Sałabun, 2019; Sałabun et al., 2020). The classical TOPSIS method has an extension regarding fuzzy logic named Fuzzy TOPSIS, which has been receiving increasing attention from the academic community (Oroojeni Mohammad Javad et al., 2020; Palczewski & Sałabun, 2019).

While other MCDM methods, such as Analytic Hierarchy Process (AHP) or ELimination Et Choix Traduisant la REalité (ELECTRE), could have been used, they lack flexibility in dealing with subjective and uncertain data that Fuzzy TOPSIS Class provides. For instance, AHP requires a more rigid structure and precise pairwise comparisons, which may not be practical in the context of sustainability reporting. In addition, AHP does not provide classification output. ELECTRE focuses more on outranking relationships, which might not capture the nuanced differences between companies in terms of how comprehensively they follow the GRI recommendations. Thus, Fuzzy TOPSIS Class was chosen for its ability to deal with subjective expert opinions and uncertain data, while providing a classification output, making it a solid fit for evaluating the complex, multi-faceted nature of sustainability reports.

By using fuzzy sets, ambiguities, inaccuracies, and the typical subjectivity of human judgment are considered, thereby improving data collection and information processing (Afrane et al., 2021). Both methods consider the notion of distance from the most desirable (Positive Ideal Solution or PIS) to the least desirable (Negative Ideal Solution or NIS) (Feitosa et al., 2021). The complement made in FTC is that the proposed alternatives or items are allocated to previously defined classes (Ferreira et al., 2018).

As detailed in this section and based on Ferreira et al. (2018), the steps for applying FTC are as follows. Figure 2 brings a diagram to aid in the visualization of the FTC process.

Step 1: Structure the decision problem by identifying decision-makers, the set of criteria, and alternatives.

Step 2: Choose linguistic terms to assess the relative importance of criteria and evaluate the ranking of alternatives. Subsequently, collect data by defining the decision matrix $\tilde{D}$ and the criteria weight vector $\tilde{W}$.

Step 3: Construct the normalized decision matrix $\tilde{R} = \left[\tilde{r}_{ij}\right]_{m \times n}$ based on the data presented in the decision matrix $\tilde{D}$ and the Equations (1) or (2) provided, depending on whether the criterion is classified as a 'benefit criterion' or 'cost criterion.'

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{d_j^*}, \frac{b_{ij}}{d_j^*}, \frac{c_{ij}}{d_j^*}, \frac{d_{ij}}{d_j^*}\right) \text{for benefit criteria, so} d_j^* = \max_i d_{ij} \tag{1}$$

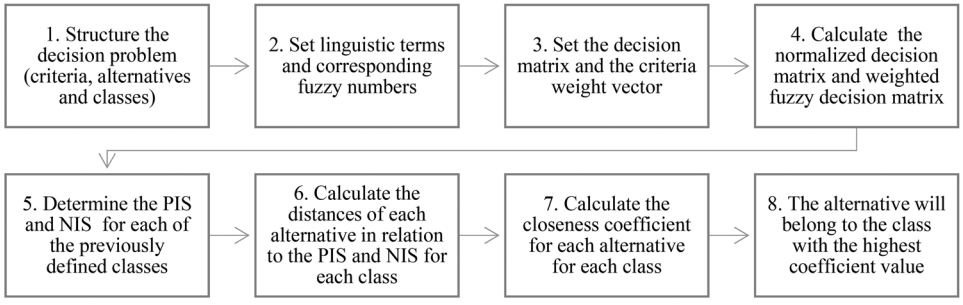

Figure 2. Overview of the FTC process. *Source:* Authors' own creation.

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{a_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{c_{ij}}, \frac{a_j^-}{d_{ij}} \right) \text{for cost criteria, so } a_j^- = \min_i a_{ij} \tag{2}$$

Step 4: Build the normalized and weighted fuzzy decision matrix $\tilde{V} = \left[\tilde{v}_{ij} \right]_{m \times n}$ by multiplying the matrix $\tilde{R} = \left[\tilde{r}_{ij} \right]$ by $\widetilde{W} = \left[\widetilde{W}_j \right]$ coas shown in Equation (3).

$$\tilde{V} = \left[\tilde{V}_{ij} \right]_{m \times n}; \tilde{V}_{ij} = \tilde{r}_{ij} \otimes \widetilde{W}_j \tag{3}$$

Step 5: Determine the PIS $\left(\tilde{A}^* \right)$ and NIS $\left(\tilde{A}^- \right)$ for each of the previously defined classes, as per Equations (4) and (5).

$$A_p^+ = \left\{ \tilde{\mathrm{V}}^+_{\mathrm{p1},} \tilde{\mathrm{V}}^+_{\mathrm{pj},} \cdots, \tilde{\mathrm{V}}^+_{\mathrm{pm},} \right\}, \tilde{\mathrm{V}}^+_{\mathrm{j}} = \tilde{q}_{pj} \tag{4}$$

$$A_p^- = \left\{ \tilde{\mathrm{V}}^-_{\mathrm{p1},} \tilde{\mathrm{V}}^-_{\mathrm{pj},} \cdots, \tilde{\mathrm{V}}^-_{\mathrm{pm},} \right\}, \tilde{\mathrm{V}}^-_{\mathrm{j}} = \tilde{q}'_{pj} \tag{5}$$

Step 6: Calculate the distances of each alternative in relation to the PIS and NIS for each class, using Equations (6) and (7).

$$\mathrm{D}_\mathrm{i}^+ = \sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{d}_\mathrm{v} \left(\tilde{\mathrm{V}}_{ij}, \tilde{\mathrm{V}}^+_{pj} \right) \tag{6}$$

where $d_v \left(\tilde{\mathrm{V}}_{ij}, \tilde{\mathrm{V}}^+_{ij} \right) = \sqrt{\frac{1}{3} \left[(\mathrm{l}_{\mathrm{ij}} - \mathrm{l}_{v^+_{pj}})^2 + (\mathrm{m}_{\mathrm{ij}} - \mathrm{m}_{v^+_{pj}})^2 + (\mathrm{u}_{\mathrm{ij}} - \mathrm{u}_{v^+_{pj}})^2 \right]}$

$$\mathrm{D}_\mathrm{i}^- = \sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{d}_\mathrm{v} \left(\tilde{\mathrm{V}}_{ij}, \tilde{\mathrm{V}}^-_{pj} \right) \tag{7}$$

where $d_v \left(\tilde{\mathrm{V}}_{ij}, \tilde{\mathrm{V}}^-_{pj} \right) = \sqrt{\frac{1}{3} \left[(\mathrm{l}_{\mathrm{ij}} - \mathrm{l}_{v^-_{pj}})^2 + (\mathrm{m}_{\mathrm{ij}} - \mathrm{m}_{v^-_{pj}})^2 + (\mathrm{u}_{\mathrm{ij}} - \mathrm{u}_{v^-_{pj}})^2 \right]}$

Step 7: Calculate the coefficient CC_i^p for each alternative for each class using Equation (8). The alternative will belong to the class with the highest value of CC_i^p.

$$CC_i^p = \frac{D_i^-}{\left(D_i^+ + D_i^- \right)} \tag{8}$$

so max$\{CC_i^p\}$ define the class to which an item belongs to.

Step 8: Conduct a sensitivity analysis to assess the robustness of the results.

For the application of the FTC, each respondent was considered as a 'criterion,' an approach also used by Pompilio et al. (2023), Bobel et al. (2022), and dos Santos et al. (2024) in the application of Fuzzy TOPSIS. The scores assigned by each respondent to each of the 12 items analyzed were weighted based on their ability to infer about the subject. This inferential capacity followed the scale presented in Table 3, and its allocation was based on the analysis of the participants' resumes. As there are uncertainties in these allocations, the application of fuzzy techniques is also appropriate at this point.

As outlined by Ferreira et al. (2018), the classes to which the evaluated items should be classified were established, as well as their TFN representations (Table 4).

It is important to note that the defined classes (Table 4) should correspond to the scale used by respondents to evaluate GRI items (Table 2) in the analyzed context, namely, the Brazilian reality. Thus, the 'unacceptable' class corresponds to the worst possible rating (most companies do not follow the

Table 3. Scale with linguistic terms used to evaluate the respondents' inferential capacity and their TFN representation.

	TFN		
Linguistic terms	***l***	***m***	***u***
Very low capacity to infer about the item in question	0.2	0.2	0.4
Low capacity to infer about the item in question	0.2	0.4	0.6
Medium capacity to infer about the item in question	0.4	0.6	0.8
High capacity to infer about the item in question	0.6	0.8	1
Very high capacity to infer about the item in question	0.8	1	1

Source: Authors' own creation.

Table 4. Predefined classes for the application of FTC with their respective TFN representations.

		TFN		
Class	Linguistic terms	***l***	***m***	***u***
Unacceptable	Most companies do not follow the recommendation	0	0	2.5
Regular	Most companies follow the recommendation in an unstructured manner	2.5	5	7.5
Adequate	Most companies follow the recommendation in a structured manner. but it is still possible to identify some deficiencies	5	7.5	10

Source: Authors' own creation.

recommendation in question). The 'regular' class represents an intermediate assessment (most companies follow the recommendation in question in a simple manner). Finally, the 'adequate' class considers the fourth-best option among the five, meaning the expectation for adequacy is that the GRI recommendation is adopted in a structured manner, but it is still possible to identify some deficiencies. This is considered, for the Brazilian context, as a good level of information in sustainability reports.

Based on the results obtained from FTC, a sensitivity analysis was conducted to assess the robustness of the findings (Stage 6), followed by discussions and establishment of the main research implications (Stage 7).

4. Results and discussions

In this research, 27 respondents assessed 12 items, with each score transformed into a triangular fuzzy number (*l*, *m*, *n*), thus generating extensive matrices (dimension 12x81). For this reason, condensed forms of the obtained matrices are presented. The decision matrix $\tilde{D}$ is shown in Table 5.

The results are based on the evaluations of 27 experts and may not represent the entire population of Brazilian companies. It is important to clarify that the study does not analyze individual companies but instead reflects the insights of 27 selected experts with deep knowledge of the general Brazilian sustainability reporting scenario. While the findings provide valuable guidance, they are specific to this expert-driven evaluation and should be interpreted as exploratory rather than representative of all Brazilian companies.

The decision matrix ($\tilde{D}$) was then normalized and weighted ($\tilde{W}$) by the respondents' ability to infer about the subject (Table 6), resulting in the matrix $\tilde{V}$ presented in Table 7. It is important to note that 77.8% of the responding academics were allocated in categories corresponding to 'high or very high capacity to infer about the item in question,' with no respondents in the 'low or very low capacity' categories.

Based on the previously defined classes (adequate, regular, and unacceptable), PIS and NIS were established for each of them as follows:

- For the 'adequate' class, the PIS corresponds to 'most companies follow the recommendation in question in a structured way, but it is still possible to identify some deficiencies' (TFN = [5, 7.5, 10]) and NIS corresponds to 'most companies do not follow the recommendation in question' (TFN = [0, 0, 2.5]);
- For the 'regular' class, PIS corresponds to 'most companies follow the recommendation in question in a simple manner' (TFN = [2.5, 5, 7.5]) and NIS corresponds to 'most companies do not follow the recommendation in question' (TFN = [0, 0, 2.5]);
- For the 'unacceptable' class, PIS corresponds to 'most companies do not follow the recommendation in question' (TFN = [0, 0, 2.5]) and NIS corresponds to 'Most companies follow the recommendation in question in a simple manner' (TFN = [2.5, 5, 7.5]).

Table 5. Decision matrix $\tilde{D}$ with the scores provided by the experts for each item.

	R1			R2			R3			R4			…	R27		
Item	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	…	*l*	*m*	*n*
IT1	2.5	5	7.5	0	2.5	5	0	2.5	5	0	0	2.5		5	7.5	10
IT2	0	0	2.5	0	2.5	5	0	0	2.5	0	2.5	5		0	2.5	5
IT3	2.5	5	7.5	0	0	2.5	0	2.5	5	2.5	5	7.5		0	2.5	5
IT4	2.5	5	7.5	0	2.5	5	2.5	5	7.5	2.5	5	7.5		2.5	5	7.5
IT5	0	2.5	5	0	2.5	5	0	0	2.5	2.5	5	7.5	…	5	7.5	10
IT6	0	2.5	5	0	0	2.5	0	0	2.5	5	7.5	10		0	2.5	5
IT7	0	0	2.5	0	2.5	5	0	2.5	5	5	7.5	10		0	2.5	5
IT8	0	2.5	5	0	0	2.5	0	2.5	5	5	7.5	10		2.5	5	7.5
IT9	0	2.5	5	2.5	5	7.5	0	2.5	5	5	7.5	10		2.5	5	7.5
IT10	2.5	5	7.5	0	2.5	5	0	2.5	5	5	7.5	10		5	7.5	10
IT11	0	2.5	5	2.5	5	7.5	0	2.5	5	5	7.5	10		0	2.5	5
IT12	2.5	5	7.5	2.5	5	7.5	0	0	2.5	0	2.5	5		0	2.5	5

Source: Authors' own creation.

Table 6. Weight vector $\widetilde{W}$ representing the inferential capacity of the experts.

Respondent	R1			R2			R3			R4			…	R27		
Fuzzy	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	…	*l*	*m*	*n*
Weights	0.6	0.8	1	0.8	1	1	0.6	0.8	1	0.8	1	1	…	0.6	0.8	1

Source: Authors' own creation.

Table 7. Matrix *m* normalized and weighed by the vector *l*, generating the matrix $\tilde{V} = \left[\tilde{V}_{ij}\right]_{mxn}$

	R1			R2			R3			…	R27		
Item	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	…	*l*	*m*	*n*
IT1	0.200	0.533	1.000	0.000	0.333	0.667	0.000	0.267	0.667		0.300	0.600	1.000
IT2	0.000	0.000	0.333	0.000	0.333	0.667	0.000	0.000	0.333		0.000	0.200	0.500
IT3	0.200	0.533	1.000	0.000	0.000	0.333	0.000	0.267	0.667		0.000	0.200	0.500
IT4	0.200	0.533	1.000	0.000	0.333	0.667	0.200	0.533	1.000		0.150	0.400	0.750
IT5	0.000	0.267	0.667	0.000	0.333	0.667	0.000	0.000	0.333		0.300	0.600	1.000
IT6	0.000	0.267	0.667	0.000	0.000	0.333	0.000	0.000	0.333		0.000	0.200	0.500
IT7	0.000	0.000	0.333	0.000	0.333	0.667	0.000	0.267	0.667	…	0.000	0.200	0.500
IT8	0.000	0.267	0.667	0.000	0.000	0.333	0.000	0.267	0.667		0.150	0.400	0.750
IT9	0.000	0.267	0.667	0.267	0.667	1.000	0.000	0.267	0.667		0.150	0.400	0.750
IT10	0.200	0.533	1.000	0.000	0.333	0.667	0.000	0.267	0.667		0.300	0.600	1.000
IT11	0.000	0.267	0.667	0.267	0.667	1.000	0.000	0.267	0.667		0.000	0.200	0.500
IT12	0.200	0.533	1.000	0.267	0.667	1.000	0.000	0.000	0.333		0.000	0.200	0.500

Source: Authors' own creation.

Table 8. Normalized and weighted values for PIS and NIS for the 'adequate' class.

Respondent	R1			R2			R3			…	R27		
Fuzzy	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	…	*l*	*m*	*n*
A_p^+	0.400	0.800	1.333	0.533	1.000	1.333	0.400	0.800	1.333		0.300	0.600	1.000
A_p^-	0.000	0.000	0.333	0.000	0.000	0.333	0.000	0.000	0.333	…	0.000	0.000	0.250

Source: Authors' own creation.

Table 9. Normalized and weighted values for PIS and NIS for the 'regular' class.

Respondent	R1			R2			R3			…	R27		
Fuzzy	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	…	*l*	*m*	*n*
A_p^+	0.200	0.533	1.000	0.267	0.667	1.000	0.200	0.533	1.000		0.150	0.400	0.750
A_p^-	0.000	0.000	0.333	0.000	0.000	0.333	0.000	0.000	0.333	…	0.000	0.000	0.250

Source: Authors' own creation.

The values defined for the classes were normalized and weighted by the criteria weights (inferential capacity of the experts), and the results for the classes 'adequate,' 'regular' and 'unacceptable' are shown in Tables 8–10, respectively.

The positive D_i^+ and negative D_i^- distances for each GRI recommendation across the three predefined classes—'Adequate,' 'Regular,' and 'Unacceptable'—have been consolidated into Table 11. This table streamlines the presentation of results, facilitating a clearer comparison of adherence levels for each recommendation. For example, IT1 and IT2 show high D_i^+ values for the 'Adequate' class and high D_i^- values for the 'Unacceptable' class, highlighting significant gaps in their adherence to GRI standards.

With the obtained values of D_i^+ and D_i^- for each class, the proximity coefficients (CC_i^p) for each item and each class were calculated, as shown in Table 12, enabling to determine the class to which an item belongs, i.e. the highest value of CC_i^p. The results presented in Table 12 demonstrate the allocation of items to their respective classes based on the calculated proximity coefficients (CC_i^p). IT1 and IT2 were classified as 'Unacceptable,' with the highest proximity coefficients of 0.610 and 0.601, respectively, for this class.

These values reflect a significant divergence from adequate and regular reporting practices. For IT1, which involves the disclosure of economic, environmental, and social impacts, this result highlights the inability of many companies to meet the minimum expectations of transparency and accountability (GRI, 2016; Cazeri et al., 2021). The lack of comprehensive and quantifiable data in this domain suggests that companies prioritize selective reporting practices or lack the resources to implement robust disclosure frameworks Cazeri et al. (2021).

Table 10. Normalized and weighted values for PIS and NIS for the 'unacceptable' class.

Respondent	R1			R2			R3			…	R27		
Fuzzy	*l*	*m*	*n*	*l*	*m*	*n*	*l*	*m*	*n*	…	*l*	*m*	*n*
A_p^+	0.000	0.000	0.333	0.000	0.000	0.333	0.000	0.000	0.333	…	0.000	0.000	0.250
A_p^-	0.400	0.800	1.333	0.533	1.000	1.333	0.400	0.800	1.333		0.300	0.600	1.000

Source: Authors' own creation.

Table 11. The positive D_i^+ and negative D_i^- distances for each GRI recommendation.

Item	Adequate D_i^+	Adequate D_i^-	Regular D_i^+	Regular D_i^-	Unacceptable D_i^+	Unacceptable D_i^-
IT1	10.917	6.982	5.880	6.982	6.982	10.917
IT2	10.755	7.146	4.934	7.146	7.146	10.755
IT3	9.768	8.098	4.415	8.098	8.098	9.768
IT4	9.397	8.773	3.611	8.773	8.773	9.397
IT5	9.308	8.597	5.544	8.597	8.597	9.308
IT6	9.838	8.032	5.712	8.032	8.032	9.838
IT7	7.101	11.252	4.528	11.252	11.252	7.101
IT8	7.827	10.061	5.596	10.061	10.061	7.827
IT9	8.646	9.230	4.413	9.230	9.230	8.646
IT10	7.524	10.876	4.939	10.876	10.876	7.524
IT11	8.106	9.920	5.138	9.920	9.920	8.106
IT12	9.214	8.633	5.300	8.633	8.633	9.214

Source: Authors' own creation.

Table 12. Values of CC_i^p and definition of the classes of each item.

	CC_i^p For each class			
Item	Adequate	Regular	Unacceptable	Final classification
IT1	0.390	0.543	**0.610**	Unacceptable
IT2	0.399	0.592	**0.601**	Unacceptable
IT3	0.453	**0.647**	0.547	Regular
IT4	0.483	**0.708**	0.517	Regular
IT5	0.480	**0.608**	0.520	Regular
IT6	0.449	**0.584**	0.551	Regular
IT7	0.613	**0.713**	0.387	Regular
IT8	0.562	**0.643**	0.438	Regular
IT9	0.516	**0.677**	0.484	Regular
IT10	0.591	**0.688**	0.409	Regular
IT11	0.550	**0.659**	0.450	Regular
IT12	0.484	**0.620**	0.516	Regular

Source: Authors' own creation.

Similarly, the classification of IT2 as 'Unacceptable' reveals systemic weaknesses in stakeholder engagement, as reflected by the marginal proximity coefficient differences between the 'Regular' (0.592) and 'Unacceptable' (0.601) classes. This close margin underscores a persistent challenge in companies' efforts to effectively address stakeholders' expectations. The findings suggest that, while some progress is evident, companies often fail to integrate stakeholder perspectives into their sustainability strategies, resulting in reports that lack inclusivity and fail to build trust (Manetti & Toccafondi, 2012; Suchman, 1995).

In contrast, the remaining items (IT3 through IT12) were predominantly classified as 'Regular,' with proximity coefficients ranging from 0.584 to 0.713. This classification indicates that companies generally meet the minimum reporting requirements but lack the depth or integration necessary to achieve 'Adequate' standards. For example, the 'Regular' classification for IT7 and IT8, which address resource efficiency and waste management, may reflect a narrow focus on isolated metrics without contextualizing them within broader sustainability objectives. This suggests that while companies are making strides in specific areas, their overall reporting practices remain fragmented and insufficiently aligned with GRI recommendations (GRI, 2013; Ye et al., 2020).

The classifications and proximity coefficients presented in Table 12 carry several implications for companies, stakeholders, and policymakers. For companies, the 'Unacceptable' classification of IT1 and IT2 serves as a critical signal to re-evaluate their sustainability reporting frameworks, particularly in areas of impact disclosure and stakeholder engagement. These shortcomings highlight missed opportunities to build trust and demonstrate accountability (Delchet-Cochet & Vo, 2013). For stakeholders, the results emphasize the need for greater scrutiny of corporate disclosures and active advocacy for more transparent and comprehensive reporting practices (Manetti & Toccafondi, 2012). Finally, for policymakers, the predominance of 'Regular' classifications underscores the necessity of regulatory interventions to standardize and enforce higher reporting standards, ensuring that companies move beyond superficial compliance towards meaningful sustainability practices (Cazeri et al., 2018).

As highlighted earlier, conducting a sensitivity analysis is crucial to demonstrate the robustness of the results (Feitosa et al., 2021). Two additional scenarios were tested. In scenario 1, a more restrictive approach to expert classification was employed, retaining only two experts (R4 and R21) at the highest level due to their distinguished resumes. In scenario 2, a more flexible approach was tested, with experts previously classified as 'average inferential capacity' now classified as 'high inferential capacity.' Table 13 presents the results obtained for the sensitivity analysis.

The results obtained for the original scenario reveal that among the twelve GRI recommendations analyzed, IT1 and IT2 are the only categories classified as 'unacceptable' by most companies. For IT1, which pertains to the disclosure of economic, environmental, and social impacts, the results indicate a systemic lack of detailed reporting. Most companies fail to provide quantitative and qualitative data necessary to assess critical dimensions such as greenhouse gas emissions, water usage, waste management, and socioeconomic contributions. This lack of transparency hinders stakeholders from comprehensively understanding the impacts of corporate activities on sustainability goals and limits companies' accountability (GRI, 2016; Freeman, 2010).

Table 13. Sensitivity analysis and comparison of results.

	Scenario 1: More restrictive				Scenario 2: More flexible			
Item	CC_i A	CC_i R	CC_i U	Changes*	CC_i A	CC_i R	CC_i U	Changes*
IT1	0.395	0.549	**0.605**	No	0.391	0.543	**0.609**	No
IT2	0.404	**0.598**	0.596	Yes (U → R)	0.403	**0.598**	0.597	Yes (U → R)
IT3	0.458	**0.654**	0.542	No	0.459	**0.658**	0.541	No
IT4	0.485	**0.715**	0.515	No	0.486	**0.715**	0.514	No
IT5	0.479	**0.607**	0.521	No	0.485	**0.616**	0.515	No
IT6	0.456	**0.589**	0.544	No	0.449	**0.588**	0.551	No
IT7	0.616	**0.716**	0.384	No	0.613	**0.714**	0.387	No
IT8	0.569	**0.646**	0.431	No	0.559	**0.640**	0.441	No
IT9	0.521	**0.679**	0.479	No	0.517	**0.678**	0.483	No
IT10	0.597	**0.692**	0.403	No	0.590	**0.691**	0.410	No
IT11	0.552	**0.659**	0.448	No	0.551	**0.663**	0.449	No
IT12	0.484	**0.618**	0.516	No	0.488	**0.622**	0.512	No

Source: Authors' own creation.
Note: A (Adequate), Regular (R) and U (Unacceptable). *Changes refer to the modifications in relation to the original scenario.

Similarly, IT2, which focuses on addressing the expectations and interests of stakeholders, reflects substantial gaps in stakeholder engagement practices (Manetti & Toccafondi, 2012). The results suggest that companies often lack formal mechanisms to identify and incorporate stakeholder input into their sustainability strategies. For instance, many companies fail to disclose how they collect and act on feedback from key stakeholders such as investors, employees, customers, and local communities. This deficiency not only reduces the perceived inclusiveness of sustainability reports but also undermines trust and credibility with stakeholders who expect meaningful dialogue and action (Ye et al., 2020).

These results highlight critical areas where Brazilian companies fall short of GRI standards, emphasizing the need for structural improvements in both impact disclosure (IT1) and stakeholder engagement (IT2). In the sensitivity analysis, IT2 transitions to the 'regular' class, indicating slight variability in the evaluations. However, this transition is marginal, as the proximity coefficient changes only at the third decimal level, underscoring the robustness of the original classification.

Addressing the shortcomings identified in IT1 and IT2 is essential for companies to align their sustainability reporting practices with international standards. Failure to do so presents risks such as diminished stakeholder trust, reputational harm, and reduced competitiveness in global markets. Conversely, improving reporting in these areas offers significant opportunities to enhance transparency, build stronger stakeholder relationships, and establish credibility in sustainability performance (Delchet-Cochet & Vo, 2013).

The absence of a thorough examination of economic, environmental, and social impacts in sustainability reporting (IT1) poses significant risks for companies. One major risk is the potential non-compliance with national legislation and internationally recognized standards (GRI, 2016; Delchet-Cochet & Vo, 2013). Failure to adhere to these regulations can lead to legal repercussions, fines, and damage to the company's legal standing. Additionally, companies may face increased scrutiny from regulatory bodies and stakeholders, resulting in reputational damage and a decline in investor confidence (Cazeri et al., 2021; Manetti & Toccafondi, 2012). Ignoring the risks associated with these impacts may hinder the company's ability to anticipate and mitigate potential challenges, impacting long-term sustainability.

For companies seeking to enhance their sustainability reporting practices, addressing IT1 presents various opportunities. Firstly, a detailed description of significant economic, environmental, and social impacts provides a foundation for improved stakeholder engagement (Freeman, 2010). By clearly outlining the effects on stakeholders and their rights, companies can build stronger relationships with their diverse audience (Cazeri et al., 2018; GRI, 2013). Enhanced transparency can also contribute to better risk management, as companies become more adept at identifying and addressing potential challenges (Ye et al., 2020). Furthermore, comprehensive reporting on challenges and opportunities related to impacts allows companies to demonstrate a proactive approach to sustainability. This can attract socially conscious investors, customers, and partners who prioritize ethical and responsible business practices (Manetti & Toccafondi, 2012). Ultimately, by addressing Item 1, companies not only fulfill reporting requirements but also position themselves as leaders in sustainable business, fostering long-term success and resilience in a rapidly changing business landscape (GRI, 2016).

On the other hand, neglecting to address IT2, which focuses on the range of reasonable expectations and interests of the organization's stakeholders, can expose companies to several risks (GRI, 2016). One significant risk is a lack of alignment with stakeholder expectations, leading to potential misunderstandings and conflicts (Freeman, 2010; Suchman, 1995). Failure to identify and acknowledge the diverse expectations of stakeholders, such as customers, employees, investors, and local communities, may result in reputational damage, strained relationships, and a loss of trust (Cazeri et al., 2021).

Additionally, aligned with the risks associated with IT1, companies may face regulatory and legal risks if they do not adequately address stakeholder expectations in their sustainability reporting. Non-compliance with stakeholder-related regulations or guidelines can lead to legal consequences and impact the company's overall standing in the market (Delchet-Cochet & Vo, 2013). In today's interconnected and transparent business environment, companies that ignore or dismiss the interests of their stakeholders, risk negative consequences that extend beyond reputation and into legal and operational realms (Freeman, 2010; Manetti & Toccafondi, 2012).

For companies looking to enhance their sustainability reporting practices, addressing IT2 presents various opportunities. Firstly, by actively identifying and addressing the range of reasonable expectations

and interests of stakeholders, companies can strengthen their relationships with key stakeholders. This includes understanding the concerns, priorities, and values of customers, employees, investors, and the broader community (GRI, 2013).

Companies that engage in meaningful dialogue with stakeholders and incorporate their expectations into sustainability reporting can build trust and loyalty (Freeman, 2010). Moreover, this engagement can lead to valuable insights that contribute to more informed decision-making and improved business strategies (Manetti & Toccafondi, 2012). Aligning reporting practices with stakeholder expectations demonstrates a commitment to transparency, accountability, and responsible corporate citizenship. Addressing IT2 also provides companies with the opportunity to showcase their responsiveness to social and environmental concerns, enhancing their reputation as socially responsible entities (GRI, 2016). This can attract socially conscious investors, customers, and partners who prioritize companies committed to meeting the expectations of diverse stakeholders.

The results of the Fuzzy TOPSIS Class analysis provide clear insights into how effectively Brazilian companies disclose key sustainability-related information. It is important to note that potential individual biases in expert evaluations may exist; however, these are accounted for and overcome using the fuzzy set theory (which mathematically computes subjectivity), translating judgments into fuzzy numbers and aggregating them, which ensures a more balanced and reliable assessment of adherence levels (Cazeri et al., 2021; Zadeh, 1996).

The analysis revealed varying degrees of adherence to the 12 GRI recommendations, with gaps in the disclosure of impacts, risks, and opportunities. For instance, while some companies provide adequate information on environmental impacts, their reporting on long-term risks—such as regulatory changes or reputational risks—remains limited (GRI, 2016; Delchet-Cochet & Vo, 2013). Additionally, many Brazilian companies fail to clearly outline opportunities for sustainability improvements, which may hinder their ability to attract socially conscious investors.

The findings of this study underscore gaps in the sustainability reporting practices of Brazilian companies, particularly in areas such as stakeholder engagement and the comprehensive disclosure of economic, environmental, and social impacts. To address these deficiencies, companies should take deliberate steps to align their practices with international standards, such as those outlined in the GRI framework (GRI, 2013).

A key starting point involves strengthening mechanisms for stakeholder engagement. By establishing structured and ongoing dialogues with stakeholders, companies can ensure that their sustainability reports are more reflective of the expectations and concerns of diverse groups, including investors, employees, and local communities (Freeman, 2010; Ye et al., 2020). This engagement not only enhances trust but also provides valuable insights that can guide strategic decision-making.

Furthermore, companies should prioritize transparency by adopting third-party verification processes for their sustainability disclosures. This step is critical for addressing stakeholder skepticism and mitigating the risks of greenwashing, which can significantly damage corporate reputation and investor confidence (Manetti & Toccafondi, 2012).

Additionally, companies must focus on improving areas identified as ‘unacceptable’ or ‘regular’ in this study, such as the inadequate reporting of key impacts and risks (IT1 and IT2). By conducting detailed assessments of their economic, environmental, and social impacts and integrating these findings into their strategic plans, companies can demonstrate a stronger commitment to sustainable practices (GRI, 2016; Cazeri et al., 2021). These actions should be complemented by internal capacity-building efforts, ensuring that employees across all levels understand the importance of accurate and meaningful sustainability reporting. By adopting these measures, companies can foster greater accountability, improve compliance with global standards, and position themselves as leaders in sustainability, thus enhancing their long-term competitiveness and resilience in an increasingly conscientious global market.

This directly addresses the research question by identifying both the strengths and weaknesses in the current sustainability reporting practices. Companies with high adherence to the GRI recommendations demonstrate better alignment with stakeholder expectations, while those with lower adherence risk undermining their credibility and investor trust (GRI, 2013; Manetti & Toccafondi, 2012).

The recommendations offered here should be understood as guidance based on the aggregated expertise of the participants. They highlight critical areas for improving adherence to GRI recommendations, particularly in transparency, stakeholder engagement, and risk disclosure. These insights are intended as exploratory and are not generalizable to all Brazilian companies. As an exploratory study, this research provides a structured methodological framework for assessing adherence to GRI recommendations (GRI, 2016). This framework serves as a foundation for future studies with larger or differently composed samples, enabling more comprehensive evaluations of sustainability reporting practices in Brazil (Cazeri et al., 2018).

In a broader perspective, results reveal that 83% of recommendations are followed in an unstructured manner and 17% are not followed at all, particularly considering the disclosure of economic, environmental, and social impacts, as well as stakeholder expectations and interests. Many developing countries face similar hurdles, including the absence of mandatory reporting frameworks and limited resources for implementing robust disclosure practices. However, Brazil's context adds a layer of complexity, given its significant environmental importance, such as its stewardship of the Amazon rainforest (Cazeri et al., 2021).

Cultural and economic factors uniquely shape the adherence of Brazilian companies to GRI recommendations. From a cultural standpoint, societal attitudes toward sustainability in Brazil often reflect regional and socioeconomic differences. In regions with stronger environmental movements or higher exposure to international markets—such as the Amazon basin or export-driven industries—there is greater pressure to demonstrate environmental responsibility. In contrast, companies in regions with less public awareness of sustainability or weaker civil society engagement may place lower emphasis on comprehensive reporting. Additionally, the perception of sustainability as a strategic priority often varies across companies, influenced by leadership values and the maturity of sustainability practices within the organization (Bertassini et al., 2021).

Economically, Brazil's long-standing economic inequalities and reliance on resource-intensive industries create structural barriers to consistent sustainability reporting. For smaller companies, particularly those in less industrialized regions, the costs associated with implementing comprehensive GRI recommendations can act as a deterrent. Furthermore, economic cycles also influence reporting behaviors, as companies in downturn periods may reduce investments in sustainability initiatives to prioritize short-term financial performance. These dynamics highlight the importance of embedding sustainability within corporate cultures and incentivizing adherence to GRI recommendations through targeted policies that address these specific cultural and economic challenges (Bertassini et al., 2021).

Improving sustainability reporting in Brazil could serve as a model for other resource-rich nations with similar socioeconomic disparities. In contrast, countries with stricter regulatory environments, such as those in Northern Europe, generally demonstrate higher consistency and depth in reporting practices. The Brazilian data underscore the importance of contextual factors, such as regulatory gaps and stakeholder pressures, in shaping reporting behavior (Cazeri et al., 2018). Lessons from global practices, such as the integration of third-party audits and standardized metrics, could help Brazilian companies bridge the gaps in transparency and accountability, aligning more closely with international standards (GRI, 2016).

Moreover, to improve adherence to GRI recommendations companies could focus on improving the disclosure of material topics by conducting systematic materiality assessments to identify and prioritize issues critical to stakeholders (Freeman, 2010; GRI, 2013). Leveraging digital reporting tools, such as integrated software or dashboards, can streamline reporting processes and ensure consistency. Furthermore, companies could articulate potential risks, including climate-related risks, more explicitly in their reports to align with stakeholder expectations and global standards. Complying with internationally recognized reporting frameworks can support adherence to GRI recommendations and provide additional clarity and comparability in reporting. Developing robust systems for data collection and verification, coupled with training programs to build expertise in sustainability reporting, could also improve the quality of disclosures. In the long term, establishing a sustainability-oriented corporate culture might, additionally, drive innovation and ensure long-term adherence to reporting standards (Bertassini et al., 2021).

5. Conclusions

Effectively assessing the quality of sustainability reports published by companies is crucial, as these reports serve as important instruments for sustainability governance and CSR. This study evaluated the sustainability reporting practices of Brazilian companies, utilizing a Fuzzy TOPSIS Class approach. Out of the twelve recommendations assessed, two were identified as highly critical, emphasizing the necessity of addressing key impacts, challenges, opportunities, and stakeholder expectations. The main risks associated with these deficiencies encompassed non-compliance with regulations, legal risks, fines, reputational damage, and diminished investor confidence, underscoring the potential long-term impact on sustainability. The sensitivity analysis conducted further demonstrated the robustness of the findings under varying scenarios.

This study concludes that while Brazilian companies have made strides in sustainability reporting, significant gaps remain in the disclosure of impacts, risks, and opportunities. These gaps represent missed opportunities for improving stakeholder engagement and could pose substantial risks if not addressed. Companies that fail to clearly communicate their sustainability impacts and associated risks may face challenges in maintaining investor confidence and meeting regulatory standards. By improving their disclosures, companies can better align with stakeholder expectations and enhance their overall transparency and accountability.

This research contributes to the field of management, particularly in the realm of sustainability management and policy. By employing a novel approach that integrates multicriteria decision analysis and fuzzy theory, critical factors for improving sustainability reporting practices were identified. The emphasis on stakeholder engagement and alignment with national and international standards highlights the relevance of robust sustainability reporting for effective management. The study provides insights for organizations aiming to enhance their sustainability reporting practices and align them with stakeholder expectations.

Fuzzy TOPSIS Class, a novel methodological approach combining multicriteria decision analysis and fuzzy theory, serves as a contribution to the field of modeling in management. This innovative method allows for a nuanced evaluation of sustainability reporting practices, incorporating uncertainties related to data and judgement. The application presented in this study opens avenues for replication in diverse settings, making it a valuable tool for researchers and practitioners interested in comprehensive sustainability assessments or other areas of management.

Another critical aspect highlighted by this study is the risk of companies misrepresenting their sustainability efforts through selective reporting or omission of material information, a practice often referred to as greenwashing. The lack of robust verification mechanisms in sustainability reporting enables such practices, which can lead to significant reputational risks, reduced investor confidence, and potential regulatory penalties. To mitigate these risks, companies must prioritize transparency and accountability by adopting third-party verification processes for their sustainability disclosures. This step ensures that reports are not only aligned with global standards but also reflect the true scope of their impacts and efforts. By addressing the risk of greenwashing proactively, companies can strengthen stakeholder trust and enhance the credibility of their sustainability practices, positioning themselves as leaders in responsible corporate behavior. These measures, when integrated with comprehensive adherence to GRI recommendations, can significantly improve the quality and reliability of sustainability reporting.

Despite the insights gained in this study, it is important to state its limitations. The reliance on expert survey data introduces potential biases, as their judgment inherently involve experience and subjectivity. In this direction, the sample size of 27 experts might not comprehensively represent the broader field of sustainability reporting in Brazil. However, the use of fuzzy linguistic representation allows for a deep and qualitative capture of expert knowledge, mitigating the need for larger sample sizes that are typically required in conventional statistical methods. This methodological choice enhances the richness and precision of the data by focusing on the inferential capacity of highly qualified experts. Furthermore, the robustness of the results was confirmed through sensitivity analysis, demonstrating the stability of the findings across different scenarios. Future research could build on these insights by expanding the sample size to include a broader diversity of perspectives, thereby enhancing generalizability.

Another limitation is that the study's focus on Brazilian companies may limit the generalizability of findings to other regions. The interpretation of the results should take the context into account, such as the social and economic characteristics of the country. Additionally, although a recognized standard was used as a base (i.e. GRI), the assessment of sustainability reporting involves a multitude of variables, and the analysis may not capture other relevant variables.

Future research could expand on this work by conducting similar analyses in different countries to provide a more comprehensive understanding of global sustainability reporting practices. Exploring the integration of emerging technologies, such as artificial intelligence or blockchain, into sustainability reporting could also yield innovative insights. Moreover, studies tracking the evolution of sustainability reporting practices over time could provide valuable insights into trends and improvements in the adherence to GRI recommendations. While CSR encompasses a wide range of practices and dimensions, this study specifically focuses on the role of GRI-based sustainability reporting as a key component of transparency and accountability. Future research could explore how adherence to GRI standards evolves over time and its impact on stakeholder trust and corporate sustainability performance.

Hence, this study sought to answer the question of how effectively Brazilian companies disclose impacts, risks, and opportunities in their sustainability reports. Using the Fuzzy TOPSIS Class method, we were able to classify companies based on their adherence to GRI standards, providing actionable insights for managers and policymakers. The findings highlight critical areas for improvement, particularly in enhancing transparency and stakeholder engagement. In a link with global practices, by adopting international best practices, such as independent verification and stakeholder-centered reporting strategies, Brazilian companies can enhance their credibility and contribute to the global push for more transparent and reliable sustainability disclosures.

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Data, materials and/or code availability

The data that support the findings of this study are available from the corresponding author, R.A., upon reasonable request.

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