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Sustainability reporting as a tool for corporate social responsibility

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ABSTRACT

Sustainability reporting is an important aspect of corporate social responsibility (CSR), enabling companies to demonstrate their commitment to issues beyond financial performance and profit. The purpose of this study is to analyse business development sustainability reporting and justify its use as an effective CSR tool. During the study, the theoretical foundations of corporate reporting were further developed by clarifying the thesaurus on accounting and reporting. The refinement of the terminology framework was complemented by the justification of updated classification criteria and types of corporate reporting in the context of sustainability requirements. The classification criteria and types of corporate reporting were justified by the following: (1) the type of indicators (financial or non-financial), (2) the standard of non-financial reporting, (3) the areas of disclosure (management, environmental, social or financial), and (4) the type of non-financial disclosure (sustainability information as part of the annual report or a separate sustainability report).

Keywords: non-financial reporting, sustainability reporting, ESG reporting, integrated reporting, corporate social responsibility, sustainable development

INTRODUCTION

Sustainability reporting is an important tool for demonstrating a company's commitment to areas beyond financial performance and profit and is therefore an important aspect of corporate social responsibility (CSR). This type of reporting includes information on a company's social, environmental, ethical and other non-financial activities. Sustainability reporting enables companies to actively respond to social and environmental challenges, setting standards for CSR. It promotes a more sustainable and responsible approach to business, contributing to the company's long-term success.

In addition to financial reporting, companies are increasingly producing other relatively new types of corporate report. To disclose information about CSR, it is important to recognise sustainability reporting as a distinct form of reporting that effectively facilitates the implementation of CSR in business.

The adoption of EU directive 2022/2464, of the European Parliament and of the Council of 14 December 2022 amending regulation no 537/2014, directive 2004/109/EC, directive 2006/43/EC, and directive 2013/34/EU, as regards corporate sustainability reporting (CDP, n. d.), the European sustainability reporting standards (ISO, 2010), and the related EU taxonomy (UN, n. d.), require new approaches to sustainability reporting that respond to modern requirements and global trends in environmental, social and governance (ESG) responsibility. These regulations aim to make corporate reporting more comprehensive and transparent, and to facilitate the transition to sustainable development. In particular, these changes are intended to:

1. Improve the quality of corporate reporting to cover not only financial indicators, but also sustainable development aspects including ESG issues.
2. Increase the transparency of reporting to enable stakeholders (investors, customers, regulators, etc.) to better assess the company's contribution to sustainable development.
3. Focus on global trends. In the context of business globalisation and a sustainable economy, corporate reporting requires compliance with international standards and regulations in order to ensure that companies remain competitive in the global marketplace.
4. Adapting the reporting process to the new standards is essential for companies that wish to continue operating in the face of the growing demand for sustainable development and ESG responsibility.

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These changes are generally aimed at making corporate reporting more comprehensive, transparent and oriented towards sustainability. To meet these requirements and ensure their competitiveness in a global economy focused on sustainable development, companies should adapt their reporting process to align with the new standards.

LITERATURE REVIEW

Over the past two decades, there has been a significant increase in scholarly interest in non-financial and sustainability reporting, driven by the growing demand for corporate transparency, stakeholder accountability, and responsible business conduct. Non-financial reporting, particularly with regard to CSR commitments, has emerged as a key factor in evaluating organisational performance beyond traditional financial metrics. This literature review summarises existing academic contributions, reveals connections between key studies, identifies knowledge gaps and highlights this research's contribution to the broader field.

Conceptual Foundations of Non-Financial Reporting

Early works focused on establishing a conceptual framework for non-financial and sustainability reporting. de Villiers et al. (2022) propose a comprehensive research agenda that integrates sustainability, value reporting and non-financial disclosures (Dimes & Molinari, 2024). Similarly, Abhayawansa and Adams (2022) argue that non-financial reporting should be positioned within a broader system of accountability that encompasses social, environmental and governance aspects.

These foundational studies emphasise the limitations of traditional financial statements in conveying a company's social and environmental impacts and highlight the need to redefine the scope of corporate reporting in the 21st century.

Regulatory Landscape: The Role of EU Directives

A significant body of literature has examined the implications of EU regulations, particularly the non-financial reporting directive (NFRD) and its successor, the corporate sustainability reporting directive (CSRD). Researchers such as Aluchna and Roszkowska-Menkes (2022) and Cuomo et al. (2022) have investigated the social and organisational impact of these directives, emphasising how regulatory pressure can encourage firms to adopt more structured and comprehensive CSR reporting practices.

Vega and de Villiers (2022) offer a comparative analysis of the NFRD's implementation in the UK, Germany, and Spain, shedding light on national disparities and enforcement challenges. Meanwhile, Breijer and Orij (2022) focus on the comparability of disclosed information, while Moggi et al. (2023) explore the institutionalisation of social accounting through mandatory reporting frameworks.

Samani et al. (2023), meanwhile, draw attention to employee-related disclosures mandated by EU directives, expanding the discussion to include internal stakeholder engagement and labour rights.

Regulatory Effectiveness and Reporting Practices

Whether regulation improves reporting quality remains a central question in academic debate. Arif et al. (2022) analyse how regulatory frameworks affect the consistency, transparency and comparability of disclosures, as do Baboukardoset al. (2023). Papa et al. (2023) examine whether regulatory intervention enhances diversity and equality in non-financial reporting.

While mandatory frameworks have increased compliance, scholars such as Pigatto et al. (2023) and Costa et al. (2022) have offered critical insights into the limitations of voluntary disclosures, citing a lack of standardisation and sector-specific benchmarks. These findings raise concerns about the actual utility of non-financial reports for stakeholders and regulators alike.

Linking Reporting to Performance and Reputation

Another area of research focuses on the relationship between non-financial reporting and various dimensions of organisational performance. Crous et al. (2022) examine the link between sustainability disclosures and financial outcomes, arguing that transparent reporting can mitigate risk and boost investor confidence. Stanescu et al. (2024) position non-financial reporting as a proxy for long-term viability and resilience.

Szadziewska et al. (2024) take a more holistic approach, exploring the intersection of sustainability, CSR and performance. Meanwhile, Dimes and Molinari (2024) investigate how reporting influences corporate governance mechanisms. Gomes et al. (2024) emphasise the importance of materiality in enhancing the relevance of sustainability information.

Sectoral and Geographical Specificities

Despite the growing volume of cross-national studies, research in emerging and transitional economies remains limited. Some studies attempt to address this gap. For example, Zhuk et al. (2020) examine non-financial reporting practices in agricultural sector and highlight significant structural and institutional deficiencies. Similarly, Di Vaio et al. (2022) analyse CSR performance in the cruise industry, while Samani et al. (2023) examine the non-financial reporting of chemical companies in the Czech Republic.

Lisi et al. (2024) investigate the challenges of non-financial reporting in small- and medium-sized enterprises, which often lack the resources and capacity to meet complex regulatory demands.

Quality, Format, and Stakeholder Engagement

The quality and credibility of disclosed information are critical concerns. Petruzzelli and Badia (2024) evaluate the extent to which stakeholder engagement is communicated in mandatory disclosures, emphasising the importance of meaningful interaction over mere symbolism. Szadziewska et al. (2024) offer a novel perspective by exploring how visual elements, such as photography, are used in reports to lend legitimacy to corporate actions and influence public opinion.

Together, these studies demonstrate that the mere existence of a sustainability report does not guarantee

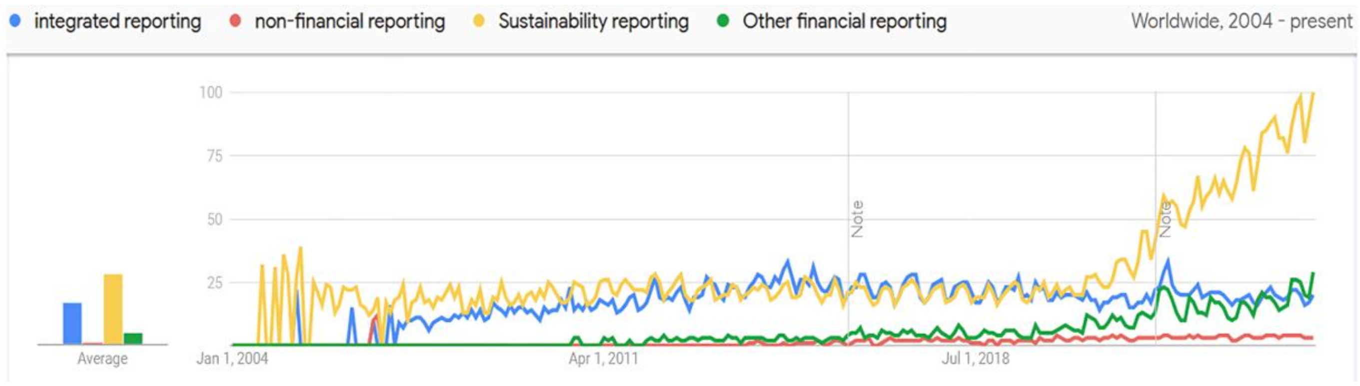

Figure 1. Dynamics of changes in search frequency by non-financial reporting categories (for the period 01 January 2004-23 February 2025) (Google Trends, n. d.)

transparency or accountability, and that the content and presentation of the report are of significant importance. Accordingly, the increasing interest among foreign researchers in this issue highlights the need for further research into the links and mutual influences of sustainability reporting within the context of CSR.

This study aims to analyse business development sustainability reporting to justify its effectiveness as a CSR tool. To achieve this, the following research objectives have been formulated:

(1) to define the economic essence of the concept of 'non-financial reporting as a tool for CSR',

(2) to develop a classification of corporate reporting in terms of sustainability requirements,

(3) to analyse the indicators of corporate sustainability reporting in the context of the International Standard Industrial Classification of Economic Activities for 2021-2022,

(4) to study statistical assessments of companies' sustainability reporting activities by country and continent, and

(5) to provide a sustainability reporting forecast.

The study's main hypothesis is that corporate sustainability reporting will become a key tool for CSR around the world if it is introduced into international reporting practice.

RESEARCH METHODOLOGY

The research design was based on revisiting and refining the theoretical principles of corporate reporting, with a particular focus on the concept of non-financial reporting as a means of achieving CSR. The research clarified accounting and reporting terminology, introducing an updated classification scheme for corporate reporting. This categorises reporting types based on the nature of the indicators (financial or non-financial), disclosure standards, and reporting domains (ESG), as well as the form of report presentation (integrated or standalone sustainability reports). Forecasts were constructed based on observed reporting trends, historical growth rates and adoption trajectories from 1993 to 2020. It is projected that the reporting rate among N100 companies will reach 91.42% by 2034 and 98.36% among G250 companies, indicating near-universal adoption among large enterprises. The modelling took into account the influence of regulatory momentum, the evolution of global standards (e.g., ESRS, GRI and ISSB) and market pressure for ESG transparency.

Data Collection Methods

Statistical data from 'Companies who report on sustainability worldwide (1993-2020)' (Statista, n. d.) and the survey 'The move to mandatory reporting: Survey of sustainability reporting 2024' (KPMG, 2024) were used to forecast sustainability reporting by the world's largest companies, as ranked by N100 and G250, by 2034. Exponential trend and autoregressive integrated moving average time series models were developed based on these data, taking into account historical dynamics of voluntary reporting practices and current changes in the regulatory environment. These models were then cross-validated using walk-forward validation to provide a 95% confidence interval for the forecast values up to 2034. Thus, a predicted curve for the spread of sustainable reporting practices among global market leaders was obtained by combining Statista (n. d.) and KPMG (2024) data.

A comprehensive assessment of the main trends in stakeholders' attitudes towards non-financial reporting issues was conducted by analysing data from Google Trends (n. d.) between 1 January 2004 and 23 February 2025 (see **Figure 1**). This analysis reveals patterns of change in searches for key terms such as 'integrated reporting', 'non-financial reporting', 'sustainability reporting', and 'other financial reporting' on Google around the world. These terms are commonly used to describe non-financial reporting methods.

This type of trend analysis is characterised by the comparability of its results. When constructing a graphical interpretation of the trend, the maximum value of search activity for the selected concept is taken into account to display the requested content. The remaining search queries for the other categories are calculated relative to this maximum value.

Based on the results of the trend analysis, it can be concluded that internet users have consistently shown a high level of interest in sustainability issues for over 21 years. Of all the terms in the sample, 'sustainability reporting' is the most frequently searched for, while 'non-financial reporting' is the least frequently searched for. The search frequency for definitions such as 'integrated reporting' and 'other financial reporting' is average.

Therefore, we recommend considering sustainability reporting as a key instrument of CSR.

Data Analysis

The research methodology is based on the statistic selection and quantitative assessment of data on the non-financial reporting of 200 companies from different countries and sectors around the world, followed by the application of forecasting methods. Companies were grouped statistically in accordance with the international standard industrial classification of all economic activities (ISIC) for the period 2021-2022. For the analysis, non-financial reports in various formats were selected. This enabled us to demonstrate the structure and dynamics of non-financial reporting on a global scale, as well as to build forecasts of its distribution.

The following methodological tools were employed to process and interpret the data:

(a) content analysis to evaluate the structure, coverage and indicators of sustainability reports,

(b) classification techniques to segment corporate reporting by sustainability criteria,

(c) trend analysis to identify historical growth patterns in sustainability reporting,

(d) comparative analysis across countries and industries to assess heterogeneity in practices, and

(e) forecast modelling using extrapolative techniques to estimate future levels of sustainability reporting among N100 and G250 companies up to 2034.

Analytical reviews and information from international institutions and professional accounting and auditing organisations on the non-financial and sustainable development reporting of 200 companies worldwide provided the empirical basis for validating the theoretical positions and ensuring the reliability of the conclusions and recommendations.

RESEARCH RESULTS

As an instrument of CSR, sustainability reporting is widely recognised as the primary means of addressing the information requirements of stakeholders with regard to economic, social and environmental indicators. This approach not only discloses and explains the activities of an economic entity in quantitative terms, but also in qualitative terms.

Analytical reviews and information from international institutions and professional accounting and auditing organisations on the non-financial and sustainable development reporting of 200 companies around the world provided the empirical basis for ensuring the validity of the theoretical positions and the reliability of the conclusions and recommendations.

A comprehensive assessment of the main trends in stakeholders' attitudes towards non-financial reporting issues was conducted by analysing data from the Google Trends (n. d.) tool between 1 January 2004 and 23 February 2025 (**Figure 1**). This analysis shows the patterns of change in searches for key terms such as 'integrated reporting', 'non-financial reporting', 'sustainability reporting' and 'other financial reporting' on the Google search engine around the world. These terms are most often used to describe the methods of non-financial reporting.

This type of trend analysis is characterised by the comparability of its results. When constructing a graphical interpretation of the trend, the maximum value of search activity for the selected concept is taken into account in order to display the requested content. For example, of the four selected categories, 'sustainability reporting' was the most popular term in February 2025, as shown in **Figure 1**. The rest of the search queries for the other categories are calculated relative to this maximum value.

Based on the results of the trend analysis, it can be concluded that internet users have consistently shown a high level of interest in sustainability issues for over 21 years. Of all the terms in the sample, "sustainability reporting" is the most frequently searched for, while "non-financial reporting" is the least frequently searched for. The search frequency for definitions such as "integrated reporting" and "other financial reporting" is average.

Therefore, we recommend considering sustainability reporting as a key instrument of CSR.

Based on our study of the various types of corporate reporting produced and disclosed by companies worldwide, we propose the following classification of reporting types. From a reporting practice perspective, we have found the following classification of non-financial reporting to be useful (**Table 1**).

Classifying corporate reporting by the nature of the indicators provides a basis for dividing it into two key types: financial and non-financial. This meets the modern requirement for transparency and the comprehensive disclosure of information about a company's activities. This division is appropriate and reasonable, as it aligns with internationally accepted approaches to financial reporting and the EU's sustainability strategy, while also allowing for a distinction to be made between traditional business performance and non-financial sustainability indicators. It also forms the basis for integrating both types of reporting within the framework of integrated reporting. Therefore, classifying reporting by the nature of the indicators enables the groundwork to be laid for analysing, comparing and developing corporate reporting in accordance with modern sustainability requirements. Furthermore, it emphasises the importance of integrating financial and non-financial aspects into companies' strategic management.

Classifying corporate reporting according to the non-financial reporting standard allows us to systematise modern approaches to disclosing information related to sustainable development, ESG factors, as well as human rights and social responsibility. This classification is particularly relevant in the context of companies transitioning to sustainable business models that consider the social and environmental impact of their activities, as well as economic feasibility. Classifying corporate reporting according to the non-financial reporting standard demonstrates the maturity of the non-financial reporting system and highlights its strategic importance to

Table 1. Proposed classification of corporate reporting based on sustainability requirements

No	Classification features	Types of reporting	Reporting standard
1	The nature of the indicators	Financial	Directive 2013/34/EU (n. d.)
		Non-financial	Directive (EU) 2014/95 (n. d.), Directive (EU) 2022/2464 (n. d.)
2	In accordance with the non-financial reporting standards	Sustainability reporting	Directive (EU) 2022/2464 (n. d.), European Sustainability Reporting Standards (2023), EU Taxonomy (2024)
		ESG reporting	Global Reporting Initiative (n. d.), Sustainability Accounting Standards Board (n. d.), TNFD (Task Force on Nature-related Financial Disclosures), CDP (n. d.), ESRS (ЄС) (European Sustainability Reporting Standards, 2023)
		Integrated reporting	IIRC Framework (Integrated Reporting Framework, International Integrated Reporting Council) (IR, n. d.)
		GRI reporting	Global Reporting Initiative (n. d.)
		Management report	Directive (EU) 2014/95 (n. d.)
		Non-financial statement	Directive (EU) 2014/95 (n. d.), CSRD (Corporate Sustainability Reporting Directive) (Directive (EU) 2022/2464, n. d.)
		CSR report	ISO 26000 (International Organization for Standardization) (ISO, 2010), Global Reporting Initiative (n. d.), internal policies of the company
		Environmental report	Espoo Convention (1991, Article 2(2), Appendix II) (Espoo Convention, 1991), Aarhus Convention (1998, Articles 5, 6(6) (Aarhus Convention, 1998), ISO 14001:2015 (Clause 9.1.1) (ISO, 2015), Global Reporting Initiative (n. d.), (GRI 301-307), Directive 2011/92/EU (n. d.) (EIA Directive, Article 5, Annex IV), Directive 2001/42/EC (n. d.) (SEA Directive, Article 5(1), Annex I), Regulation (EU) 2020/852 (n. d.) — EU Taxonomy Regulation (Articles 3, 19), Directive (EU) 2022/2464 Corporate Sustainability Reporting Directive (CSRD) (Article 1(3), Annex II) (Directive (EU) 2022/2464, n. d.)
		Report on gender equality and diversity	GRI 405 (Global Reporting Initiative, n. d.), UN Women's Empowerment Principles, SASB Diversity Metrics (Sustainability Accounting Standards Board, n. d.)
		Green finance report/sustainable finance disclosure	EU SFDR (Sustainable Finance Disclosure Regulation) (SFDR, n. d.), EU Taxonomy (2024), TCFD (n. d.), ICMA Green Bond Principles (ICMA, n. d.)
		Human rights report	UN Guiding Principles on Business and Human Rights (OHCHR, n. d.), GRI 412 (Global Reporting Initiative, n. d.), OECD guidelines (OECD, n. d.)
3	By areas of disclosure	Management	Management, operating environment, corporate responsibility
		Ecological	Environment and ecology
		Social	Gender issues, inclusion, and human rights
		Financial	Financial disclosures
4	According to the method of disclosure of non-financial statements	Information on sustainability in the management report	Directive (EU) 2022/2464 (n. d.), Article 1(15), Directive 2013/34/EU (n. d.), Article 29b(1)
		Separate sustainability report	Directive (EU) 2022/2464 (n. d.)

stakeholders. It provides a basis for an integrated approach to risk management, accountability and long-term value creation. Implementing it strengthens business sustainability and compliance with regulatory requirements, thereby increasing confidence in companies.

Analysing the classification of corporate reporting by disclosure area allows us to organise information according to a company's core activities and impact. This provides a solid basis for comprehensively understanding its sustainability, responsibility and management efficiency. This classification takes an interdisciplinary approach to reporting, treating non-financial aspects as equally important as financial ones. Classifying by disclosure area emphasises a multidimensional approach to reporting, whereby companies demonstrate not only their financial results, but also their responsibility to society, the environment and employees. This approach helps to increase trust in business, manage risks more effectively, and integrate sustainability into strategic planning.

The non-financial reporting disclosure method allows information to be presented either as part of the management report or as a standalone report. This allows companies to choose the format that best suits the disclosure of non-financial aspects of their activities, depending on the information requirements of stakeholders.

The proposed classification streamlines non-financial reporting, providing a clearer understanding of it and facilitating the preparation and disclosure of information by companies, as well as the making of economic decisions by key stakeholders. Furthermore, it paves the way for methodological approaches to be developed for assessing and integrating non-financial indicators into the corporate governance system.

Classifying corporate reporting in terms of sustainability requirements is an important analytical tool that promotes standardisation and improves the quality of disclosure, while also integrating sustainable development principles into corporate governance systems.

Accordingly, we analysed data from companies that prepare sustainability reports, grouping them according to the ISIC for the 2021-2022 period (**Table 2**).

Table 2. Enterprises that reported on sustainable development within the framework of the ISIC for the 2021-2022 period

No	ISIC			Name of the company	n	P (%)
	S	Unit	Description			
1	A	01-03	Agriculture, forestry and fishing	Avangard, Astarta-Kyiv, MHP, Nibulon, Cygnet, IMC, Adecoagro, Avebe, Oceana Group Ltd, Phosagro, Sea Harvest Group Ltd, Syngenta, Tecnologica de Alimentos SA	13	6.50
2	B	05-09	Mining and quarrying	Aveng, BHP, Brikor limited, DRA Global Ltd, Glencore plc, Gold Fields Ltd, Kumba Iron Ore Ltd, MC Mining Limited, Pan African Resource plc, Royal Bafokeng Platinum Ltd, SableExploration&Mining, Sibanye Stillwater Ltd, South32 Limited, Tharisa plc	14	7.00
3	C	10-33	Manufacturing	PJSC «Obolon», ArcelorMittal, Argent Industrial Limited, Barloworld, BAT, Bosch, Distell, Doosan, Fosagro, Hulamin Ltd, Italtile Ltd, Metair Investments Ltd, Mondeliza, Mpact Limited, Nampak Ltd, Nestlé, Omnia Holdings Ltd, Philip Morris International, Reunert Ltd, Sasol Limited, Stafer, Tiger Brands Ltd, Tongaat hulett limited, Trellidor Hldgs Ltd, Votorantim, York Timber Holdings Ltd	25	12.50
4	D	35	Electricity, gas, steam and air conditioning supply	NAFTOGAZ Group, DTEK, 2A Group's, Afrox, Efora energy limited, Escom, Exxaro Resources Ltd, Omi group, TenneT Holding, Terna, Xcel Energy	11	5.50
5	E	36-39	Water supply; sewerage, waste management and remediation activities	-	-	-
6	F	41-43	Construction	Acciona, BAM, Bouygues Group, Calgro M3 Hldgs Ltd, Holcim, Kajima Group, Stefanutti Stck Hldgs Ltd, Sunway Construction, Tokyu Construction, TRC Construction Public Company Limited, Wilson Bayly Hlm-Ovc Ltd	11	5.50
7	G	45-47	Wholesale and retail trade; repair of motor vehicles and motorcycles	Bidvest Ltd, Cashbuild Ltd, Choppies Enterprises Ltd, Dis-Chem Pharmacies Ltd, Fairvest Limited, Mustek Ltd, Nictus Ltd, Nippon Steel Trading's strengths, Shoprite Holdings Ltd, Woolworths Holdings Ltd	11	5.50
8	H	49-53	Transportation and storage	Ukrzaliznytsia, Atlantia, Deutsche Bahn, Grindrod Ltd, ID logistics, Imperial, La poste, Logisteed, Maersk, Nippon Express, Raubex Group Ltd	11	5.50
9	I	55-56	Accommodation and food service activities	Accor Group, City Lodge Hotels Ltd, Famous Brands Ltd, House Foods Corporation, IHCL, RCL Foods Limited, Sun international, Tsogo Sun Hotels, Valamar Riviera, Yoshinoya holdings	10	5.00
10	J	58-63	Information and communication	Kyivstar, Lifecell, SoftServe, Blue label telecoms limited, Bytes Technology Group Plc, Datatec, EOH Holdings Ltd, KPN, Metrofile Holdings Ltd, MTN Group Ltd, PBT Group Limited, SAP, Telkom SA SOC Ltd, Vodacon	14	7.00
11	K	64-66	Financial and insurance activities	ABN AMRO Bank, Capitec Bank Hldgs Ltd, Clientele Ltd, Discovery Holdings, Ellies Holdings Ltd, Finbond Group Ltd, Firstrand, Industrials REIT Limited, Nedbank Group Ltd, Old Mutual Limited, Rebosis property fund limited, SAIB, Sasfin Holdings Ltd, Shaftesbury Capital plc, Standard Bank Group Ltd, Sygnia Limited, Trustco Group Hldgs Ltd, Truworths Int Ltd, UniCredit, Universal Partners Ltd, Vancity, Vunani Ltd, Workforce Holdings Ltd	23	11.50
12	L	68	Real estate activities	Attacq limited, Capital Appreciation Ltd, Liberty Two Degrees Ltd, NEPI Rockcastle N.V., Putprop Ltd, Redefine, Resilient REIT Limited, Safari Investments RSA Ltd, Sirius Real Estate Ltd, Stor-Age Prop REIT Ltd, Texton Property Fund Ltd, Thungela Resources Ltd, Vukile Property Fund Ltd	13	6.50
13	M	69-75	Professional, scientific and technical activities	BDO Ukraine, ACCA, Arguden Governance Academy, CBUS, CPA Australia, IFAC, IFRS Foundation, International Federation of Red Cross and Red Crescent Societies, JLL, North-West University, OMRON Corporation	11	5.50
14	N	77-82	Administrative and support service activities	-	-	-
15	O	84	Public administration and defence; compulsory social security	-	-	-
16	P	85	Education	State University of Trade and Economics (Ukraine), Abertay University, Advtech, Hokkaido University, Newcastle University, Okayama University, Stellenbosch University, The University of Edinburgh, The University of Salford, University of Tsukuba, University of Winchester	11	5.50
17	Q	86-88	Human health and social work activities	Farmak, Adcock ingram, Ascendis Health, Aspen, Astellas Pharma Inc, Clicks Group Ltd, Grifols, Mediclinic Int plc, Philips, RH Bophelo Limited, Royal DSM	11	5.50
18	R	90-93	Arts, entertainment and recreation	-	-	-
19	S	94-96	Other service activities	Adcorpgs limited, ATNS, AYO, Edenred Group, INFRONEER Holdings, LTIMindtree Limited, Murray & Roberts Hldgs, Repsol, Ricoh Group, SGS	11	5.50
Total					200	100

Note. S: Section; n: Number of enterprises and units; & P: Percentage of enterprises

To conduct this analysis, we selected 200 companies from various countries and sectors which produce non-financial reports in different formats. This was done to gain an understanding of the structure and dynamics of non-financial reporting on a global scale.

To determine the extent of non-financial reporting, we categorised the selected companies by country and continent (**Table 3**).

We created a visualisation showing the percentage of countries reporting on sustainable development based on **Table 2** (**Figure 2**). An analysis of a sample of 200 enterprises located on different continents that use various types of non-

Table 3. Companies that compile sustainability reports by country and continent

No	Continent	Country	Enterprise	n	P (%)
1	Australia	Australia	BHP, CBUS, CPA Australia, DRA Global Ltd, MC Mining Limited, South32 Limited	6	3.0
Total by continent Australia				**6**	**3.0**
2	Asia	India	IHCL, LTIMindtree Limited	2	1.0
		Cyprus	Tharisa plc	1	0.5
		Malaysia	Sunway Construction	1	0.5
		South Korea	Doosan	1	0.5
		Saudi Arabia	SAIB	1	0.5
		Thailand	TRC Construction Public Company Limited	1	0.5
		Turkey	Arguden Governance Academy	1	0.5
		Japan	Astellas Pharma Inc, Hokkaido University, House Foods Corporation, INFRONEER Holdings, Kajima Group, Logisteed, Nippon Express, Nippon Steel Trading's strengths, Okayama University, OMRON Corporation, Ricoh Group, Tokyu Construction, University of Tsukuba, Yoshinoya holdings	14	7.0
Total by continent Asia				**22**	**11.0**
3	Africa	Botswana	Choppies Enterprises Ltd	1	0.5
		Mauritania	Universal Partners Ltd	1	0.5
		Namibia	Trustco Group Hldgs Ltd	1	0.5
		South Africa	Adcock ingram, Adcorpgs limited, Advtech, Afrox, Argent Industrial Limited, Ascendis Health, Aspen, ATNS, Attacq limited, Aveng, AYO, Barloworld, Bidvest Ltd, Blue label telecoms limited, Brikor limited, Calgro M3 Hldgs Ltd, Capital Appreciation Ltd, Capitec Bank Hld0,gs Ltd, Cashbuild Ltd, City Lodge Hotels Ltd, Clicks Group Ltd, Clientele Ltd, Dis-Chem Pharmacies Ltd, Discovery Holdings, Distell, Efora energy limited, Ellies Holdings Ltd, EOH Holdings Ltd, Escom, Exxaro Resources Ltd, Fairvest Limited, Famous Brands Ltd,Firstrand, Grindrod Ltd, Hulamin Ltd, Imperial, Italtile Ltd, Kumba Iron Ore Ltd, Liberty Two Degrees Ltd, Metair Investments Ltd, Metrofile Holdings Ltd, Mpact Limited, MTN Group Ltd, Mustek Ltd, Nampak Ltd, Nedbank Group Ltd, Nictus Ltd, North-West University, Oceana Group Ltd, Old Mutual Limited, Omnia Holdings Ltd, Pan African Resource plc, PBT Group Limited, Putprop Ltd, Raubex Group Ltd, RCL Foods Limited, Rebosis property fund limited, Redefine, Resilient REIT Limited, Reunert Ltd, RH Bophelo Limited, Royal Bafokeng Platinum Ltd, SableExploration&Mining, Safari Investments RSA Ltd, Sasfin Holdings Ltd, Sea Harvest Group Ltd, Shoprite Holdings Ltd, Sibanye Stillwater Ltd, Standard Bank Group Ltd, Stefanutti Stck Hldgs Ltd, Stellenbosch University, Stor-Age Prop REIT Ltd, Sun international, Sygnia Limited, Telkom SA SOC Ltd, Texton Property Fund Ltd, Thungela Resources Ltd, Tiger Brands Ltd, Tongaat hulett limited, Trellidor Hldgs Ltd, Trustco Group Hldgs Ltd, Truworths Int Ltd, Tsogo Sun Hotels, Vodacon, Vukile Property Fund Ltd, Vunani Ltd, Wilson Bayly Hlm-Ovc Ltd, Woolworths Holdings Ltd, Workforce Holdings Ltd, York Timber Holdings Ltd	88	44.0
Total by continent Africa				**91**	**45.5**
4	Europe	Great Britain	Abertay University, ACCA, BAT, Bytes Technology Group Plc, Datatec, Gold Fields Ltd, IFRS Foundation, Industrials REIT Limited, JLL, Mediclinic Int plc, Newcastle University, Shaftesbury Capital plc, Sirius Real Estate Ltd, The University of Edinburgh, The University of Salford, University of Winchester	16	8.0
		Denmark	Maersk	1	0.5
		Spain	Grifols, Omi group, Repsol	3	1.5
		Italy	A2A Group, Acciona, Atlantia, Stafer, Terna, UniCredit	6	3.0
		Luxembourg	ArcelorMittal	1	0.5
		Netherlands	ABN AMRO Bank, Avebe, BAM, KPN, NEPI Rockcastle N.V., Philips, Royal DSM	7	3.5
		Germany	Bosch, Deutsche Bahn, Fosagro, SAP	4	2.0
		Ukraine	Avangard, Astarta-Kyiv, DTEK, DTEU, Kyivstar, MHP, NAFTOGAZ, Nibulon, Obolon, BDO LLC, Ukrzaliznytsia, Farmak, Cygnet, IMC, Kernel, Lifecell, Softserve	18	9.0
		France	Accor Group, Bouygues Group, Edenred Group, ID logistics, La poste	5	2.5
		Croatia	Valamar Riviera	1	0.5
		Switzerland	Glencore plc, Holcim, IFAC, Nestlé, SGS, Syngenta, TenneT Holding, International Federation of Red Cross and Red Crescent Societies	8	4.0
Total by continent Europe				**70**	**35.0**
5	South America	Argentina	Adecoagro	1	0.5
		Brazil	Votorantim	1	0.5
		Peru	Tecnologica de Alimentos SA	1	0.5
Total by continent South America				**3**	**1.5**
6	North America	Canada	Vancity	1	0.5
		United States	Finbond Group Ltd, Mondeliza, Murray & Roberts Hldgs, Philip Morris International, Sasol Limited, Xcel Energy, Phosagro	7	3.5
Total by continent North America				**8**	**4.0**
Total				**200**	**100**

Note. n: Number of enterprises & P: Share of enterprises

financial reporting, including sustainability reporting (**Table 2**), reveals the following trends:

- Africa tops the list for the preparation of such reports with 91 reports (45.5%),
- Europe comes second with 70 reports (35%),
- third place is occupied by Asia (22 reports or 11%),
- fourth place by South America (8 reports or 4%), and

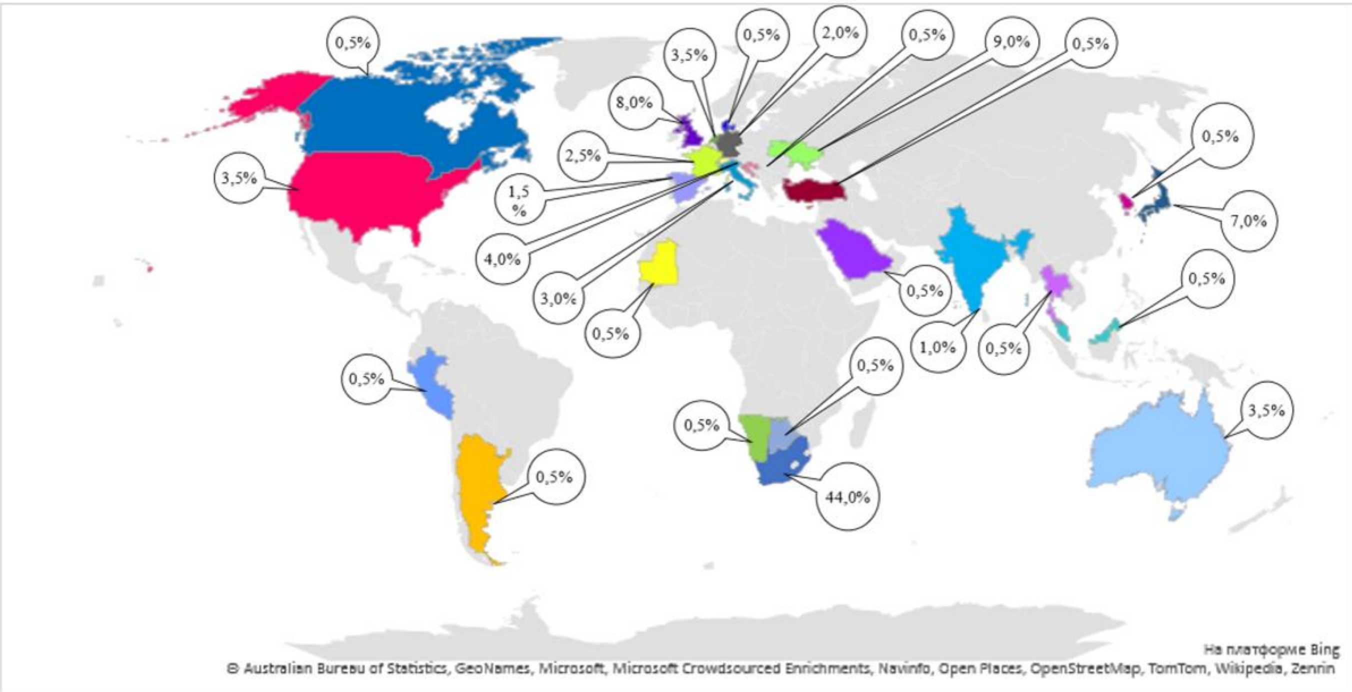

Figure 2. Percentage of countries worldwide that prepare sustainability reports (Source: Authors' own elaboration, based on data from 200 companies that prepare non-financial reports)

- fifth place by Australia (6 reports or 3%), and last place by South America (3 reports or 1.5%).

In terms of the number of integrated reports generated and submitted under the IR (n. d.), the Republic of South Africa was the leader in Africa (88 reports, accounting for 96.7% of all countries on the continent), while Botswana, Mauritania and Namibia were joint second (one report each, accounting for 1.1%).

Among European countries, Ukraine tops the list for the number of submitted and published non-financial reports (18 reports, accounting for 25.71% of the total). The UK is second (16 reports, accounting for 22.86% of the total), the Netherlands is third (seven reports, accounting for 10% of the total), and Italy is fifth (six reports, accounting for 8.57% of the total).Switzerland occupies third position (eight reports, accounting for 11.42%); the Netherlands occupies fourth position (seven reports, accounting for 10%); Italy occupies fifth position (six reports, accounting for 8.57%); France occupies sixth position (five reports, accounting for 7.14%); Germany occupies seventh position (four reports, accounting for 5.71%); Spain occupies eighth position (three reports, accounting for 4.29%); and Denmark, Luxembourg and Croatia occupy ninth position (one report each, accounting for 1.43%).

In Asia, Japan tops the list with 14 reports (63.64%), followed by India with two reports (9.09%). Other countries with one report each are Cyprus, Malaysia, South Korea, Saudi Arabia, Thailand and Turkey (4.54%).

In South America, the USA ranks first in terms of the number of non-financial and other types of reports prepared and submitted (seven reports, or 87.5%), while Canada ranks second (one report, or 12.5%).

In Australia, only one country produces non-financial reports (six reports).

Among South American countries, Argentina, Brazil and Peru lead the way in terms of the number of submitted and published non-financial reports (one report each, representing 33.33%).

Representatives of many international institutions and professional organisations have discussed the need for companies to prepare and submit non-financial and sustainability reports. White (n. d.), CEO of International Federation of Accountants (IFAC), for example, noted that accountants play a key role in ensuring the quality of sustainability information. He emphasised that the new guidelines would help them fulfil this responsibility, contributing to the building of trust and the global transformation of sustainable development. This highlights the vital role of the accounting profession in developing transparent and reliable reporting that meets the requirements of modern business and society.

Forbes council member Sierra (n. d.) notes that good corporate governance means managers are aware of their company's impact on stakeholders, can respond to their needs and are prepared for future challenges. Conversely, Maria Mendiluce, CEO of the We Mean Business Coalition, emphasises that reliable sustainability reporting hinges on robust management and control processes. She believes that improving the quality of sustainability information and linking it to financial reporting is crucial for companies seeking to take ambitious climate action and attract investors interested in sustainable growth. This confirms that sustainability is not an isolated aspect of a company's activities but should be integrated into financial processes and corporate strategy.

Jim Knafo, CEO of the Global Accounting Alliance, adds that professional accountants are well placed to ensure that sustainability information meets the high standards of transparency and quality demanded by stakeholders. He emphasises the need to standardise reporting and compliance approaches in line with international requirements, which would provide a consistent basis for comparing and analysing companies' activities.

de Nuccio, a former board member of the IFAC, emphasises the necessity of regulating integrated reporting if we are to realise its full value and enable users to compare companies within a particular sector of the economy (IFAC, 2024). Without accounting standards that allow for comparison and enable investors to allocate capital appropriately, our capital markets would not be as large or efficient as they are today. Accounting standards also enable companies to benchmark their performance and encourage continuous improvement. Stock exchanges such as BM&FBOVESPA (the Brazilian stock exchange), the Bombay Stock Exchange, Borsa Italiana (Euronext), the Dhaka Stock Exchange, Deutsche Börse (the German exchange), Euronext Paris, Hong Kong Exchanges and Clearing Limited, and the South African stock exchange require non-financial information to be presented as part of corporate entities' integrated reporting. Therefore, regulation is required to define the scope of integrated reporting and the standards to be used in preparing such reports.

Sokolenko, the head of the Association of Sustainable Development Experts and an international expert on sustainable finance, notes that, during the war, there were many crises and challenges and that the prospect of sustainable societal development seemed uncertain (USAID, 2023). Nevertheless, he believes that the key principles of sustainable development must be incorporated into every national policy decision at all levels. In other words, despite wars around the world, sustainable development remains a priority for future generations. Power (2023), administrator of the USAID, emphasised that joint efforts would encourage private investment in Ukraine, which is essential for short-term economic recovery and building a prosperous future for the country.

Therefore, modern accountants play a vital role in fostering trust in sustainable development. This requires them to develop new competencies, adapt to international standards and prepare traditional financial statements. By acting as intermediaries between companies, investors and other stakeholders, they help to ensure transparent and efficient information flows. At the same time, further methodological approaches to sustainability assessment should be developed, and common standards need to be implemented to promote global consistency and the reliability of non-financial and sustainability reporting.

Table 4. Sustainability reporting by the world's largest companies in the N100 and G250 rankings

No	Years	N100, %	G250, %
1	2011	64.00	95.00
2	2013	71.00	93.00
3	2015	73.00	92.00
4	2017	75.00	93.00
5	2020	80.00	96.00
6	2022	79.00	96.00
7	2024	79.00	96.00
8	**2026**	***81.70****	***96.51****
9	**2028**	***84.13%****	***96.97%****
10	**2030**	***86.56%****	***97.44%****
11	**2032**	***88.99%****	***97.90%****
12	**2034**	***91.42%****	***98.36%****

Note. *Forecast indicator calculated by the authors using an exponential smoothing quantitative model in MS Excel

In early 2022 (Integrated, n. d.; Statist, n. d.), the IASB conducted a study to determine where and how sustainability reporting is being implemented, and the results were highlighted in a report. The study revealed significant uptake in various economic sectors worldwide. **Table 4** shows global sustainability reporting indicators for the period 2011-2024.

Based on **Table 4**, we have created a forecast of the sustainability reporting practices that the world's largest companies, as ranked by the N100, are expected to adopt by 2034 (**Figure 3**).

Analysis of the data in **Figure 3** shows that the proportion of sustainability reports published by the world's largest

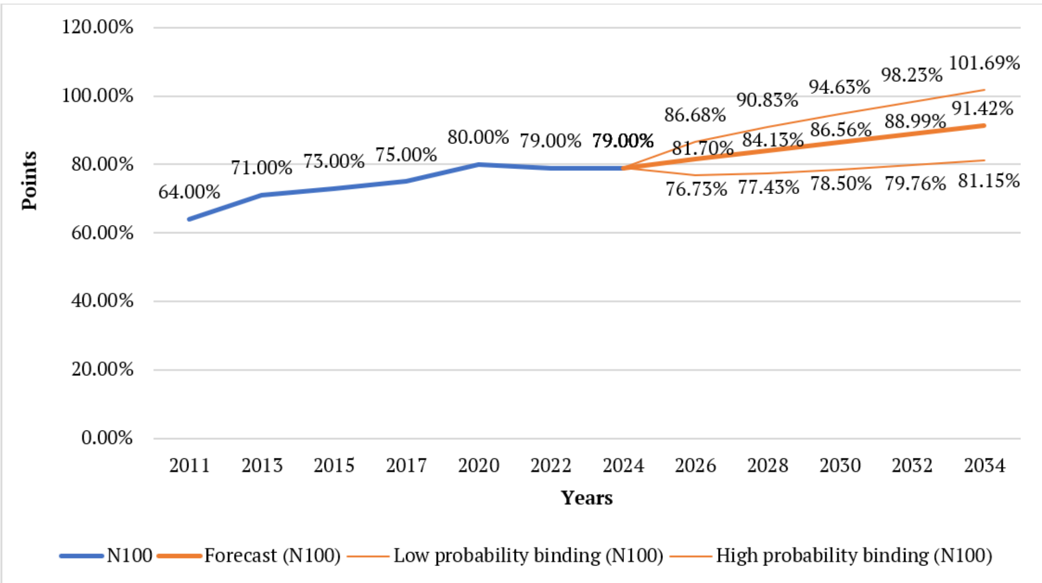

Figure 3. Forecast* of sustainability reporting by the world's largest companies included in the N100 rating (*calculated using an exponential smoothing quantitative model in MS Excel) (generated by the authors based on the **Table 3**).

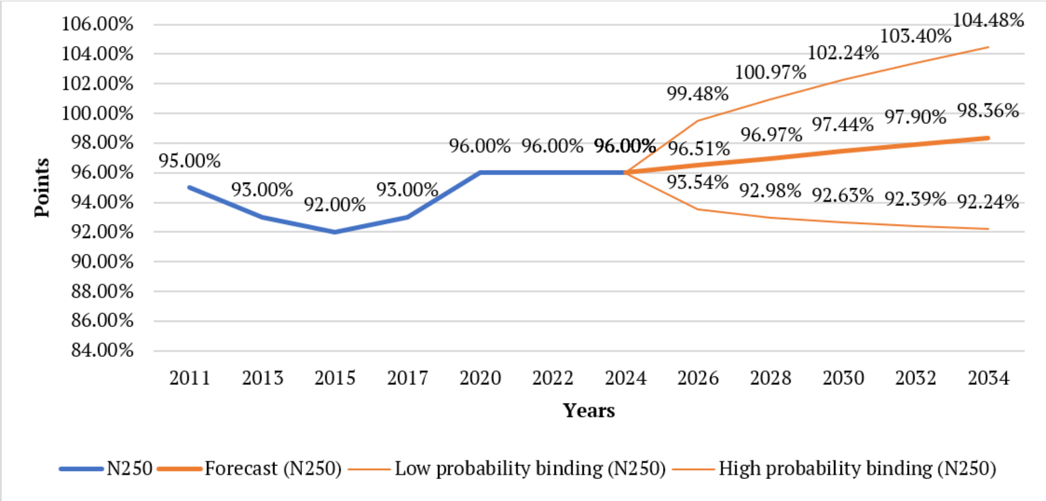

Figure 4. Forecast* of sustainability reporting by the world's largest companies, as ranked by the G250 (*calculated using an exponential smoothing quantitative model in MS Excel) (generated by the authors based on **Table 3**)

companies, as ranked in the N 100, increased from 64% in 2011 to 79% in 2024 (a rise of 15 percentage points). The largest increase in sustainability reporting, at 5%, was observed between 2017 and 2020. After 2020, sustainability reporting stabilised at 79% in both 2022 and 2024. Forecasting sustainability reporting by the world's largest companies in the N100 ranking up to 2034 indicates a potential increase to 91.42%, suggesting a rise in the number of reports of this type.

We have also produced a forecast for sustainability reporting by the world's largest companies in the G250 ranking up to 2034 (**Figure 4**).

As shown in **Figure 4**, the analysis indicates that the level of sustainability reporting among the world's largest companies, as ranked by the G250, has remained consistently high, ranging from 92% in 2015 to 96% in 2024. The highest value of this indicator was recorded in 2020 (96%), a level expected to be maintained between 2022 and 2024. It is forecast that 98.36% of the world's largest companies included in the G250 rating will submit such reports by 2034, confirming the high level of interest in non-financial reporting among the largest corporations.

Taking the above into account, we can draw conclusions about why sustainability reporting might become popular in certain regions:

1. Increased attention to sustainable business development. Many African countries, for instance, are confronted with intricate environmental, social, and economic development challenges. Including non-financial indicators in reports enables businesses and organisations to understand and enhance their environmental and social impacts, thereby promoting sustainable development.
2. Attracting investors. Many international investors and funds consider not only financial performance, but also corporate social and environmental responsibility. Public sustainability reporting provides insight into how a company manages risks and its environmental impact, helping to attract investors.
3. Improving corporate governance. Sustainability reporting encourages companies to adopt transparent and responsible business practices. This builds trust between companies and their stakeholders, ensuring more effective governance.
4. Development of regulatory and legal support for sustainability reporting. International organisations such as the International Integrated Reporting Council, the Sustainability Accounting Standards Board, and the Value Reporting Foundation are actively involved in this work. For example: The International Integrated Reporting Framework and the International Standard on Sustainability Assurance 5000, 'General Requirements for Sustainability Assurance Engagements'. The adoption of the CSRD (Directive (EU) 2022/2464) has provided a strong impetus for sustainability reporting, establishing categories and groups of companies for which preparing sustainability information is mandatory. These regulations simplify the process of preparing, compiling, submitting, approving and publishing sustainability reports, thereby making them more accessible to companies in different regions.
5. Regulatory requirements. Some countries may introduce reporting requirements that include non-financial indicators. This could encourage companies to produce sustainability reports to fulfil these obligations.

Although sustainability reporting can have many positive aspects, its use varies by country, region and business sector. For example, the success of integrated reporting in Africa was preceded by a coordinated approach involving government agencies, businesses, and civil society. Of course, sustainability reporting is not limited to developing countries, nor is it dependent on their level of economic development.

DISCUSSION

The results of the study on the use of sustainability reporting as a means of CSR reveal several interesting findings that warrant further discussion. Taking into account the classification of corporate sustainability reporting developed for this study, as well as the analysis of reporting structures by country and the forecast of their development until 2034, it is possible to draw several important conclusions regarding the practical and theoretical challenges in this area.

One of the study's key outcomes is the development of a sustainability reporting classification, which systematises existing approaches to the issue. The study found that classification is a prerequisite for standardising and streamlining reporting practices at an international level. In particular, Abhayawansa and Adams (2022) emphasise the need to include pandemic- and climate change-related risks in the conceptual framework of non-financial reporting. To provide a more comprehensive view of companies' responsibilities, environmental risks and social challenges must become integral to reporting.

Conversely, critics may highlight the challenge of implementing a single classification system in light of the diversity of national standards and practices, as discussed by Bini et al. (2023). The absence of a universal reporting methodology can hinder accurate cross-country and cross-company data comparisons.

Analysing the structure of sustainability reporting in different countries can reveal trends that will influence the future of non-financial reporting. For example, the RU's NFRD has led to an increase in information on social and environmental issues (Arif et al., 2022). Conversely, countries with less developed economies and institutions may struggle to adapt to such standards.

Publications such as those by Aluchna and Roszkowska-Menkes (2022) note that countries with lower levels of corporate responsibility tend to have poorer reporting quality and less transparency in their reports. This can create inequalities at an international level and hinder the integration of CSR into global supply chains.

Furthermore, Breijer and Orij (2022) emphasise the importance of considering industry-specific factors when preparing non-financial reports. Therefore, it is crucial that countries adapt their reporting standards to consider industry-specific factors and national contexts.

The study's outlook on sustainability reporting in 2034 offers valuable insights into the impact of evolving social, environmental and economic conditions on CSR practices. The diversity of reporting approaches observed across countries will lead to the evolution of reporting standards and methods. This will include integrating new technologies, such as artificial intelligence and big data, to enable more accurate assessment and monitoring of environmental and social aspects.

de Villiers et al. (2022) predict that reporting will be even more integrated by 2034, combining financial and non-financial indicators. This will enable businesses to assess the impact of their activities on sustainable development more accurately. An increasing number of companies are expected to report on their contribution to the UN sustainable development goals, thereby ensuring that social, environmental and economic factors are integrated into management strategies.

However, publications by authors such as Arif et al. (2022) suggest that an increase in reporting volume could lead to a decline in quality due to a lack of specialist skills or inadequate adaptation to new technologies. Therefore, the current provisions for discussion in this area of non-financial reporting leave space for further research.

CONCLUSIONS

During the study, the theoretical foundations of corporate reporting were further developed by clarifying the thesaurus on accounting and reporting. The focus was on the concept of 'non-financial reporting as an instrument of CSR', i.e., a component of corporate reporting used by enterprises to take responsibility for society and meet stakeholders' information needs regarding economic, social, and environmental issues.

Sustainability reporting involves collecting and presenting a company's financial and non-financial activities in a single report, including economic, social and environmental indicators. The main purpose of such a report is to provide stakeholders with comprehensive and balanced information about business processes that takes sustainable development into account.

Sustainability reporting, as well as non-financial reporting in general, is a relevant and important tool in the modern business world of economically developed countries. However, it is also becoming increasingly common in developing countries, regardless of their level of economic development. Many countries are supporting and encouraging the preparation of sustainability reports and other non-financial reports, and this practice is becoming increasingly common. This enables companies to provide more transparent and effective reports, build trust with social groups and investors, and promote sustainable business and economic development in the long term.

The clarification of terminology was supplemented by the justification of the updated classification of corporate reporting types in terms of sustainability requirements:

(1) the nature of the indicators (financial or non-financial),

(2) the non-financial reporting standard,

(3) the disclosure areas (management, environmental, social and financial), and

(4) the non-financial reporting disclosure method (sustainability information as part of the management report or in a separate sustainability report).

This multi-level classification facilitates the transition from a fragmented to a systematic understanding of corporate sustainability reporting and establishes the foundations for effective analytical, accounting and management support in the pursuit of sustainable enterprise operations.

Additionally, an analysis of the structure and dynamics of non-financial reporting at country level was conducted, covering reports from 200 enterprises in various economic sectors. Based on the available data, forecasts of the dynamics of non-financial reporting were produced. Notably, the anticipated increase in sustainability reporting coverage among the largest N100 companies, which is expected to reach 91.42% by 2034, indicates the continued consolidation of non-financial reporting as an integral part of transparent corporate communication. This also highlights the growing importance of sustainability as a strategic consideration for companies in the global market.

The forecast for non-financial reporting among the G250 by 2034 is 98.36%, effectively indicating the widespread adoption of sustainability reporting by the world's largest companies. This suggests that the corporate sector has largely adapted to the new standards of transparency, responsibility and accountability. Consequently, G250 companies are demonstrating leadership in sustainable development, setting an example for smaller businesses and confirming the irreversibility of the trend towards the globalisation of non-financial reporting.

Several important practical considerations can be identified when taking into account the three key aspects of the study: the development of a classification of corporate reporting in terms of sustainability requirements; the analysis of reporting structures by country; and the forecasting of sustainability reporting developments.

1. Creating a classification of corporate reporting in terms of sustainability requirements systematises existing approaches to such reporting and facilitates the integration of sustainable practices into corporate strategies. This classification allows enterprises to clearly define and track their contribution to sustainable development within the context of financial and non-financial information. It significantly increases transparency, ensuring more accurate monitoring and avoiding declarative reporting, whereby companies declare their commitment to sustainable development without making any real changes to their strategy. The practical significance of this classification is that it helps companies prioritise their sustainability initiatives and adjust their strategies based on clear criteria.
2. Analysing the structure of sustainability reporting in different countries allows us to identify global trends and differences in reporting approaches among companies in different regions. This enables the practical application of the best international practices and their adaptation to national conditions. Furthermore, understanding the reporting structure, including the criteria, standards, and indicators employed in various countries, enables Ukrainian companies to enhance their reporting and become more competitive in the global market. Identifying key indicators for sustainable development in line with national and international standards enables the creation of more consistent and reliable methodologies for assessing CSR.
3. Forecasting the development of sustainability reporting up to 2034 is crucial for shaping future corporate strategies and sustainability policies. Such a forecast can help identify key trends that will influence future reporting requirements, such as the adoption of new technologies and digitalisation in reporting, as well as the integration of ESG factors into business practices. Such a forecast enables companies to prepare for changes in international standards and national regulations, allowing them to adapt their strategies in time to meet future requirements. It also allows sustainability researchers and practitioners to anticipate potential changes in markets and regulatory systems.

Limitations of the study

Despite its valuable findings and contributions to our understanding of sustainability reporting as a tool for CSR, this study has several limitations that must be acknowledged.

1. The empirical basis of the research was limited to sustainability reports from 200 enterprises. While these reports provided valuable insights into reporting practices and identified key trends, they may not accurately reflect the diversity of global practices, particularly in sectors or regions with lower reporting rates. Thus, the generalisability of the results should be treated with caution.
2. The quality and consistency of non-financial and sustainability reporting varies significantly between countries and industries, and even within sectors. This inconsistency may have affected the accuracy of cross-country comparisons and limited the ability to draw robust conclusions about reporting maturity and transparency levels.
3. Forecasts of sustainability reporting coverage among N100 and G250 companies up to 2034 are based on current trends and extrapolated data. However, they may not account for unexpected regulatory, economic or geopolitical developments that could significantly alter the trajectory of sustainability reporting adoption.
4. Although the study proposed a classification of corporate reporting based on sustainability criteria, the analysis was largely theoretical and descriptive. Further quantitative validation through econometric modelling or statistical correlation analysis could strengthen the classification.
5. Using historical data up to 2020, with projections up to 2034, may not capture recent changes to sustainability reporting frameworks, such as the introduction of the new ESRS, and the increasing emphasis on double materiality.

Recognising these limitations creates opportunities for future research to address these gaps by using more comprehensive datasets, employing longitudinal designs, adopting a stakeholder-centred approach, and applying advanced quantitative techniques. Such efforts would strengthen the evidence base for understanding and improving sustainability reporting as a cornerstone of CSR.

Suggestions for Future Research

We believe that developing the methodological foundations for auditing sustainability reports is a promising area for further research, as this would confirm their reliability and strengthen businesses' CSR.

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Ethical statement: The authors stated that, throughout the study, the authors adhered strictly to the highest ethical benchmarks for scholarly publications, ensuring practices such as informed consent, anonymity, and confidentiality were rigorously upheld. The authors further stated that the authors noted that no institutional ethical clearance was deemed necessary, given that the dataset employed was fully anonymized, no human biological samples were involved, and the investigation did not induce any significant distress among participants.

AI statement: The authors stated that no generative AI tools were used during the study.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from corresponding author.

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