Journal of Accounting in Emerging Economies

# Do women on corporate boards enhance biodiversity disclosure? Evidence from South Africa

Reon Matemane and Titus Ayobami Ojeyinka
*Department of Financial Management, University of Pretoria, Pretoria, South Africa*
Abongeh A. Tunyi
*Swansea University, Swansea, UK and Department of Financial Governance, College of Accounting Sciences, University of South Africa, Pretoria, South Africa, and*
Tesfaye Lemma
*Towson University, Towson, Maryland, USA*

Received 7 February 2025
Revised 7 July 2025
14 September 2025
Accepted 19 September 2025

## Abstract

**Purpose** – This study investigates whether board gender diversity enhances biodiversity disclosure among listed firms in South Africa. Drawing on legitimacy theory, resource-based view and critical mass theory, we examine the extent to which female board representation drives more comprehensive biodiversity reporting, particularly in environmentally sensitive sectors, and whether a threshold effect strengthens this relationship.

**Design/methodology/approach** – We use panel data comprising 1,016 firm-year observations from 254 Johannesburg Stock Exchange–listed firms between 2018 and 2021. The analysis relies on OLS regressions with industry and year-fixed effects, as well as firm-fixed effects models. We further test for the presence of a critical mass effect, investigate sectoral heterogeneity and perform robustness checks using alternative specifications and strategies to address endogeneity concerns.

**Findings** – The results provide strong and consistent evidence that board gender diversity is positively associated with biodiversity disclosure. This effect is stronger in firms with three or more female directors and in environmentally sensitive industries, although it is also present among non-financial firms more broadly. The positive association is concentrated in disclosure dimensions related to policies, targets, and governance, but is not evident in more technical areas such as biodiversity valuation, risk quantification, and impact measurement. This suggests that gender-diverse boards may drive strategic commitment but not necessarily technical implementation.

**Practical implications** – The findings highlight the importance of gender diversity as a governance lever for promoting biodiversity accountability, but also suggest it must be complemented by technical capacity, environmental expertise, and organizational systems. Policymakers, investors and sustainability advocates should view board gender diversity as an enabling factor that requires additional support to translate commitment into comprehensive reporting.

**Originality/value** – This study extends the literature by providing novel evidence on the governance determinants of biodiversity disclosure in an emerging market context. It unpacks the heterogeneous nature of biodiversity reporting and shows that board composition influences strategic disclosure elements more than technical ones. The findings have implications for corporate governance reform, disclosure policy and research on gender and sustainability.

**Keywords** Biodiversity disclosure, Gender diversity, Critical mass, Corporate boards, South Africa

**Paper type** Research article

## 1. Introduction

The preservation of natural resources has become a central concern in environmental and sustainability accounting (Issa and Zaid, 2023). As biodiversity plays a crucial role in sustaining life and economic activity, firms are increasingly expected to disclose their impacts on ecosystems (Carvajal *et al*., 2022; Bebbington and Larrinaga, 2014; Dutta and Dutta, 2023). Biodiversity underpins essential ecosystem services—such as oxygen production, air and

Journal of Accounting in Emerging Economies
© Emerald Publishing Limited
e-ISSN: 2042-1176
p-ISSN: 2042-1168
DOI 10.1108/JAEE-02-2025-0058

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water purification, pollination, and waste treatment—that are vital to human well-being (Jones and Solomon, 2013; Haque and Jones, 2020). Gaia and Jones (2020) further emphasize the inextricable link between ecosystem health and human survival, reinforcing the urgency of conservation efforts. This imperative has been recognized through global initiatives such as the United Nations Convention on Biological Diversity, the Sustainable Development Goals [1], and sustainability reporting frameworks like the Global Reporting Initiative (Schneider *et al*., 2014; Maione *et al*., 2024; Talbot and Boiral, 2021). Consequently, firms are under growing pressure to provide meaningful biodiversity disclosures, prompting researchers to explore the organizational and governance factors that shape such reporting—particularly in developing economies, where biodiversity risks are acute but institutional pressures may be weaker.

In this context, our study investigates the role of board gender diversity as a governance mechanism influencing biodiversity disclosure among listed firms in South Africa. Boards play a central role in setting corporate strategy and shaping environmental engagement (Ali *et al*., 2024; Simsek *et al*., 2024; Areneke *et al*., 2023; Luo and Tang, 2021; Saha and Khan, 2024; Tunyi *et al*., 2023; Hussain *et al*., 2023). Drawing on upper-echelon theory, prior research suggests that director characteristics, including gender, influence board oversight and decision-making, especially in areas such as sustainability and corporate social responsibility (Areneke and Tunyi, 2022; Bravo, 2018; Khaireddine *et al*., 2020). Female directors are often associated with more ethical, inclusive, and long-term orientations, which may enhance transparency and environmental accountability (Tunyi *et al*., 2023). However, research also highlights the problem of tokenism, where female appointments serve symbolic purposes without conferring substantive influence (Lee and Thong, 2023; Wang *et al*., 2024). This raises important questions about whether female board representation in developing countries can meaningfully improve biodiversity disclosure—an issue that has received limited empirical attention.

While prior studies have explored the role of board composition in shaping environmental, social, and integrated reporting (Joshi, 2018; Baalouch *et al*., 2019; Orazalin and Baydauletov, 2020; Nuskiya *et al*., 2021; Martiny *et al*., 2024), very few have examined biodiversity disclosure specifically, and even fewer have done so in emerging markets (Rimmel and Jonall, 2013; Haque and Jones, 2020; Elsayed, 2023; Hassan *et al*., 2022; Dutta and Dutta, 2023). South Africa offers a particularly relevant setting for this inquiry. It is the third most biodiverse country in the world, home to over 95,000 species and three globally recognized biodiversity hotspots—the Cape Floristic Region, the Succulent Karoo, and the Maputaland-Pondoland-Albany Centre of Endemism (Tolley *et al*., 2019). South Africa ratified the Convention on Biological Diversity in 1997 and has adopted policies such as the National Development Plan (Vision, 2030) to promote environmental sustainability. Furthermore, integrated reporting—including biodiversity information—is mandated for listed firms (Jones and Solomon, 2013). Yet, gender diversity on corporate boards remains uneven. While the Government Gazette, Act No 55 (1998) encourages diversity, there are no binding gender quotas for board composition (Ntim and Soobaroyen, 2013; Hollindale *et al*., 2019). This institutional context allows for meaningful variation in both gender diversity and biodiversity disclosure, making it a compelling case for empirical analysis.

As a starting point, we set out to investigate two main propositions. First, we hypothesize that board gender diversity is positively associated with biodiversity disclosure, consistent with arguments about the ethical and sustainability orientation of female directors (Tunyi *et al*., 2023). Second, we explore whether a critical mass of female representation (typically defined as three or more women) is necessary to produce observable improvements in disclosure, following literature that distinguishes symbolic from substantive representation.

Our analysis is based on a hand-collected dataset covering 254 firms listed on the Johannesburg Stock Exchange (JSE) between 2018 and 2021, yielding 1,016 firm-year observations. Biodiversity disclosure data is sourced from the National Biodiversity and Business Network (NBBN) Biodiversity Disclosure Project, while financial and governance

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data are extracted from firm reports and financial databases. We estimate a range of models, including OLS with industry and year fixed effects and panel regressions with firm-fixed effects. We conduct additional analyses to assess the effect of a critical mass of female directors and test for heterogeneity across environmentally sensitive industries. To address endogeneity concerns, we use propensity score matching and entropy balancing, along with fixed effects and clustered robust standard errors.

Our results reveal a robust and statistically significant positive association between board gender diversity and biodiversity disclosure among South African listed firms. This relationship is particularly strong in firms with three or more female directors, providing empirical support for the critical mass perspective. The effect is also more pronounced in environmentally sensitive industries, where biodiversity risks are likely to be more salient, but remains evident across the broader population of non-financial firms. These findings align with the ethical values hypothesis, which posits that female directors are more attuned to social and environmental concerns, thereby strengthening board commitment to sustainability.

Importantly, our dataset allows us to assess not only whether gender diversity improves biodiversity disclosure, but also how it influences the content and quality of such disclosures. We find that gender-diverse boards are significantly associated with strategic and governance-related dimensions of biodiversity reporting. These include the articulation of biodiversity policies, the setting of strategic targets, the formulation of action plans, and the implementation of monitoring systems. However, board gender diversity appears to have limited influence on more technical and data-intensive aspects of disclosure—such as the valuation of biodiversity, the measurement of dependencies and impacts, and the reporting of biodiversity-related risks and performance metrics.

This pattern suggests that while gender-diverse boards may drive high-level commitment and oversight, the implementation of technically detailed biodiversity practices likely depends on other organizational or institutional factors, such as environmental expertise, data infrastructure, or industry-specific regulations. As such, gender diversity may serve as an important enabling condition for biodiversity accountability, but not a sufficient one for comprehensive disclosure across all dimensions.

Our study makes three main contributions. First, we provide one of the first large-sample empirical investigations of the relationship between board gender diversity and biodiversity disclosure in a developing economy. By focussing on South Africa, we contribute to a more geographically and institutionally diverse literature on corporate sustainability governance. Second, we offer empirical support for the critical mass theory, demonstrating that a threshold number of women on the board is required for meaningful improvements in biodiversity disclosure. Third, we use detailed, disaggregated biodiversity data to explore not just whether firms disclose, but what they disclose. This allows us to differentiate between symbolic and substantive aspects of reporting and highlights the need to consider the heterogeneity of disclosure content in governance research.

The rest of this paper is organized as follows: Section 2 reviews the related literature and develops our hypotheses, Section 3 presents our data and methodology, Section 4 presents and discusses our findings, and Section 5 concludes the study.

## 2. Literature review and hypothesis development

### *2.1 Biodiversity and biodiversity disclosure*

Biodiversity, short for biological diversity, refers to the variety of life on Earth — from genes to entire ecosystems — that works in unison to maintain balance and support life. Jones and Solomon (2013) describe biodiversity as the essential infrastructure supporting all life while the Convention on Biological Diversity sees biodiversity as the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems, along with the complex interactions within them.

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Biodiversity disclosure is a specialized form of non-financial reporting that falls under the broader umbrella of corporate social responsibility (CSR), sustainability accounting, and integrated reporting (Jones and Solomon, 2013; Vola *et al*., 2021). It provides information on how a firm's operations affect ecosystems, capturing both harmful impacts on biodiversity and mitigation efforts. This form of disclosure is particularly important for demonstrating accountability to stakeholders, especially in environmentally sensitive industries such as basic materials, energy, manufacturing, and extractives, where business activities often pose direct risks to natural habitats. Even firms in less visibly polluting sectors, such as banking, may indirectly contribute to biodiversity loss through financing projects with adverse environmental consequences (Buallay and Alhalwachi, 2022).

While environmental disclosure broadly refers to corporate reporting on ecological impact, risks, and compliance, covering aspects such as emissions, waste management, and regulatory adherence, biodiversity disclosure represents a more specific subset (Jones and Solomon, 2013). It focuses on how business activities affect the diversity of flora and fauna and the integrity of ecosystems. Under the JSE sustainability guidelines, biodiversity is recognized as a key environmental metric, requiring firms to assess and report on their influence on natural habitats and species. In this sense, biodiversity disclosure offers a distinct yet complementary lens to conventional environmental and sustainability reporting, highlighting issues that are often underrepresented in standard disclosures (Atkins and Maroun, 2015).

Given the centrality of biodiversity to ecosystem functioning and human wellbeing, the neglect of biodiversity in corporate reporting represents a critical gap. Biodiversity loss ranks among the top five global risks (Elsayed, 2023) and is increasingly linked to broader systemic issues, including supply chain disruptions, ecosystem degradation, and threats to food and health systems (Roberts and Elamer, 2025). Scholars argue that enhanced biodiversity disclosure can play a pivotal role in addressing these risks by promoting transparency and encouraging firms to internalize the ecological consequences of their actions (Haque and Jones, 2020; Elsayed, 2023). By focussing explicitly on biodiversity-oriented reporting, this study contributes to a growing yet still underdeveloped strand of the environmental disclosure literature.

Beyond traditional stakeholders, groups such as environmentalists, international organizations, and local communities are increasingly interested in firms' non-financial impacts, particularly regarding ecosystem preservation. A failure to provide comprehensive environmental information can undermine a firm's legitimacy and future operations (McKinsey, 2010). Indeed, prior research (Bonini and Oppenheim, 2010) suggests that a firm's reputation in biodiversity hotspots hinges on its biodiversity stewardship, as effective disclosure communicates its environmental impact to stakeholders. Moreover, environmental disclosure, including biodiversity reporting, may reduce information asymmetry between shareholders and management (Cormier *et al*., 2005). Thus, biodiversity reporting is an essential tool for organizations to demonstrate their commitment to biodiversity conservation and maintain stakeholder trust.

Despite the critical role of biodiversity conservation in human survival, empirical studies indicate that its disclosure as a corporate objective remains generally low. Jones and Solomon (2013) highlights the significance of addressing biodiversity loss and identifies biodiversity reporting as the most effective means of revealing the impact of corporate activities on natural habitats. However, the limited research on biodiversity reporting suggests that most organizations disclose little or no information on their biodiversity-related activities. For instance, Grabsch *et al*. (2011) found low levels of biodiversity reporting among firms in the UK and Germany. Similarly, Van Liempd and Busch (2013) and Rimmel and Jonall (2013) documented minimal biodiversity disclosure among publicly listed companies in Denmark and Sweden. Van Liempd and Busch (2013) further reported that UK and German firms in the telecommunications and financial sectors provided no biodiversity-related information in their annual reports. Consistent with these findings, Jones (2014) observed a similar lack of disclosure among UK and German-listed companies, while Addison *et al*. (2019) noted that

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biodiversity reporting had yet to gain significant traction among Fortune 100 Global companies. More recently, Haque and Jones (2020) confirmed this trend, reporting low levels of biodiversity disclosure among 4,013 firms across 13 European countries.

*2.2 Theoretical background*

Theoretically, various perspectives have been proposed to highlight the importance of environmental and biodiversity disclosure as a key component of non-financial reporting. Agency theory, for instance, suggests that when firms disclose adequate and substantial information, information asymmetry is reduced, and principal-agent conflicts are mitigated (Jensen and Meckling, 1976; Khaireddine *et al*., 2020). However, our study is grounded in legitimacy theory, resource dependency theory, and critical mass theory, as they are particularly relevant to the relationship between gender diversity and biodiversity disclosure.

Gray *et al*. (1995) identify legitimacy as a socially centred theory that provides a comprehensive framework for discussing and understanding social and environmental reporting. Proponents of legitimacy theory view environmental, including biodiversity, reporting as a "social contract" between firms and the communities in which they operate (Cho and Patten, 2007; Bhattacharyya and Yang, 2019; Matemane *et al*., 2022). According to the principles of legitimacy theory, firms are expected to adhere to relevant social charters to ensure their continued operation (Welbeck *et al*., 2017). Consequently, to secure community support and maintain business sustainability, firms must provide a thorough account of their impact on living organisms — both plant and animal — as part of their corporate reporting (Chelli *et al*., 2014).

Proponents of resource dependency theory argue that female board members possess both human and relational capital, which can influence board decisions on environmental performance, including biodiversity disclosure (Hollindale *et al*., 2019; Haque and Jones, 2020). Originating from the work of Pfeffer and Salancik (1978), resource dependency theory suggests that a diverse and gender-balanced board allows an organization to access a broader range of resources, skills, expertise, and knowledge from its external environment compared to a homogenous board dominated by male directors. In this context, gender diversity on the board serves as a crucial mechanism for securing essential external resources. Hillman *et al*. (2007) further highlight three key benefits of female board representation within the framework of resource dependency theory: advice and counsel, legitimacy, and favourable access to resources. They identify female board members as valuable assets that firms can leverage to enhance environmental reporting. Based on this premise, legitimacy theory and resource dependency theory provide the theoretical foundation for understanding the pivotal role of women directors as a governance mechanism — one that facilitates resource acquisition, protects shareholder interests, reduces agency costs, and ultimately promotes greater disclosure of biodiversity-related activities.

The third theoretical foundation utilized in this study is critical mass theory. Rooted in the work of Kanter (1977), critical mass theory posits that the number of women on a corporate board must reach a certain threshold before they can exert a significant influence on board decisions. Proponents of critical mass theory argue that merely having female directors on a board is insufficient for their voices to be effectively heard on critical matters (García-Meca *et al*., 2024; Tunyi *et al*., 2023). According to Torchia *et al*. (2011), a single female director on a board is considered a "token", two women signify "presence", and three or more constitute a "voice". Board gender scholars further contend that for women to meaningfully contribute to board decisions, a minimum threshold of female representation must be met. Below this threshold, women are often perceived as tokens with limited influence (Dahlerup, 2006; Schwartz-Ziv, 2017; Tawiah *et al*., 2024). This threshold, referred to as the critical mass, is key to ensuring that female directors can actively shape boardroom discussions and decisions. Indeed, several studies have shown that a critical mass of female directors improves the quality of governance within the firm, leading to

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positive firm outcomes (Wiley and Monllor-Tormos, 2018; Rahman *et al*., 2023; Jayaraman *et al*., 2024).

*2.3 Empirical review and hypothesis development*

*2.3.1 Prior empirical literature.* A wealth of research exists on voluntary reporting, particularly in areas such as environmental reporting, corporate social responsibility, and social accounting, across both developed and developing countries (Welbeck *et al*., 2017; Okafor *et al*., 2022; RIP *et al*., 2023). However, studies specifically addressing biodiversity reporting — especially in developing economies like South Africa — remain limited (Buchling and Maroun, 2023). Most existing research in this area has focused on countries such as the U.S., UK, Canada, Austria, and other European nations (Rimmel and Jonall, 2013; Adler *et al*., 2017; Bhattacharyya and Yang, 2019; Haque and Jones, 2020; Carvajal *et al*., 2022; Velte, 2023). For instance, Haque and Jones (2020) examine the impact of gender diversity on biodiversity disclosure, analyzing data from 4,013 firms in European countries between 2002 and 2016. Their study used biodiversity impact assessments and biodiversity disclosure initiatives as proxies and found that gender diversity positively influences biodiversity indicators among European firms. Similarly, Bhattacharyya and Yang (2019) investigate the effect of the Global Reporting Initiative adoption on biodiversity disclosure in Australia, reporting a significant increase in biodiversity-related disclosures among Australian listed firms following this adoption. Similarly, Velte (2023) examines the relationship between sustainable board governance and biodiversity disclosure among listed firms in Europe, concluding that stronger board governance is associated with increased biodiversity disclosure. To the best of our knowledge, whether board gender diversity impacts biodiversity disclosure amongst emerging market firms remains an unexplored issue. We contribute to the extant literature by investigating the influence of board gender diversity on biodiversity reporting in the South African context. The development of the study's hypotheses is briefly discussed below.

*2.3.2 Board gender diversity and biodiversity disclosure.* The relationship between board diversity and environmental reporting is a compelling area of research. Gender diversity, in this context, refers to the proportion of female board members relative to their male counterparts in a firm's highest decision-making body. In recent years, there has been growing interest in increasing female representation in corporate boardrooms (Tingbani *et al*., 2020; Tunyi *et al*., 2023). This interest arises from the belief that female board members, through their human relations skills and stakeholder-oriented approach, can influence board decisions to promote environmentally sustainable practices, including efforts to mitigate risks of biodiversity loss (Haque and Jones, 2020).

Orazalin and Baydauletov (2020) identify board gender diversity as a key driver of environmental sustainability. Similarly, Hollindale *et al*. (2019) argue that female board members possess valuable human and relational capital, which enhances firms' environmental reporting. Prior studies exploring disclosure in developed world contexts document that firms with a higher proportion of female board members tend to disclose more environmental information (Adams and Ferreira, 2009; Post *et al*., 2015; Glass *et al*., 2016; Buallay and Alhalwachi, 2022). For example, Haque and Jones (2020) analyzed 4,013 listed firms across 13 European countries and found that greater female representation on corporate boards enhances sustainability reporting. They further argue that female board members are more attuned to relationship-building and societal concerns regarding biodiversity loss (Haque and Jones, 2020). Similarly, Tingbani *et al*. (2020) observed that board gender diversity promotes voluntary disclosure of greenhouse gas (GHG) emissions among UK firms. Recent findings by Carvajal *et al*. (2022) confirm that female board representation enhances biodiversity reporting among U.S. firms. Likewise, Issa and Zaid (2023) found that the presence of women on corporate boards leads to better biodiversity disclosure initiatives among non-financial firms in 13 European countries. There is also some, albeit, limited evidence of the role of

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women in enhancing sustainability disclosures amongst firms in developing world contexts. For example, Toerien *et al*. (2023) examined non-financial reporting in 92 JSE-listed firms and found a positive relationship between gender diversity and the level of ESG disclosure.

Notwithstanding, some studies produce contrasting results by showing that board gender diversity negatively impacts environmental reporting. For example, Galbreath (2011), Rao and Tilt (2016), and Ghabayen *et al*. (2016) find that board gender diversity negatively affects environmental reporting in different settings. Meanwhile, Prado-Lorenzo *et al*. (2009) and Fernandes *et al*. (2018) report no significant association between board gender diversity and environmental disclosures. More recently, Hambali and Adhariani (2024) found no significant relationship between gender diversity and corporate biodiversity disclosure across 27 countries. Given these mixed findings, Moreno-Gómez *et al*. (2018) suggest that the question of whether female board members enhance environmental performance remains unresolved.

Building on prior research findings that female board members have superior human relations skills and are more ethical, sustainability-minded, and stakeholder-oriented (Haque and Jones, 2020; Tunyi *et al*., 2023), we contend that they will enhance biodiversity disclosure in a context like South Africa, where biodiversity protection is of paramount interest to stakeholders. We advance the following hypothesis:

*H1*. Board gender diversity positively impacts biodiversity disclosure among the listed firms in South Africa.

*2.3.3 The importance of a critical mass of female representation.* Recently, the concept of critical mass regarding female board representation and its impact on environmental disclosure has garnered attention from scholars (Nuber and Velte, 2021; Yarram and Adapa, 2021; De Masi *et al*., 2021; García-Meca *et al*., 2024). These studies argue that for female directors to significantly influence board decisions on important environmental and societal issues, their representation on the board must reach a minimum threshold, typically three members. For example, De Masi *et al*. (2021) report that having at least three female directors ensures greater transparency in reporting and enhances the quantity of ESG disclosures in Italy. Similarly, Yarram and Adapa (2021) provide evidence of a critical mass effect, showing that firms meeting this threshold of three women are more likely to engage in positive CSR activities. However, the study by Kutlu Furtuna and Sönmez (2024) found that a critical mass of women directors had no significant impact on voluntary climate disclosure among listed firms in Turkey. While most empirical studies on critical mass have focused on its impact on environmental disclosure in general, none have specifically examined its effect on biodiversity disclosure, especially in the context of emerging economies such as South Africa. Therefore, based on the insights reviewed above and in relation to H1, we hypothesize that a critical mass of female directors will facilitate better and more comprehensive disclosure of biodiversity-related activities, as outlined in the following hypothesis:

*H2*. Critical mass of women directors is positively associated with greater biodiversity disclosure in South Africa.

## 3. Research methodology

### *3.1 Sample selection*

This study aims to examine the influence of gender diversity on biodiversity disclosure among the listed firms on the Johannesburg Stock Exchange (JSE) between 2018 and 2021. The selection of the sample is guided by the availability of data on the key variable —biodiversity disclosure. Biodiversity data on South African firms is not readily available in any dataset we are aware of. The National Biodiversity and Business Network (NBBN) launched a Biodiversity Disclosure Project for South African companies. As part of this project, the NBBN generated biodiversity performance ratings for several firms listed on the JSE. The ratings, which we further discuss below, are based on disclosures made by the companies.

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The ratings cover the period from 2018 to 2021. Over 327 JSE-listed firms were included in the 2021 ratings. We use the 327 firms for which ratings are available as our sample for this study. We manually hand-collect the ratings data and match this to firm financial and governance data, which we manually collect from firm financial reports. Out of the 327 companies covered by the NBBN ratings, 73 firms did not subsequently have complete governance data. Since our interest is in female representation on corporate boards, we exclude these 73 firms from our sample. Our final sample covers 254 listed firms over four years (2018–2021), resulting in 1,016 firm-year observations.

Table 1 provides the distribution of sampled firms across 10 industries. The table reveals that the financial sector has the highest number of observations, which accounts for 19.3% of the sample size, while the energy sector is the least, accounting for 1.6% of the total observations. Prior studies typically exclude the financial sector from their analysis due to their unique reporting requirements. We do not exclude them from our main analysis but conduct additional robustness checks to evidence that our results remain robust if we only consider non-financial firms.

### *3.2 Model specification and variable measurement*

Premised on the extant studies on biodiversity disclosure (Bhattacharyya and Yang, 2019; Dutta and Dutta, 2023), the study specifies the following model to examine the effects of board gender diversity on biodiversity reporting among the listed firms in South Africa.

$$\begin{aligned}\text{Biodiversity Disclosure}_{it} = \; & \beta_0 + \beta_1 \text{Board Gender Diversity}_{it-1} \\ & + \sum \beta_k \text{Controls}_{it-1} + v_j + v_t + \epsilon_{it}\end{aligned} \tag{1}$$

*Biodiversity Disclosure* constitutes the dependent variable in the study. Empirical studies on biodiversity disclosure, particularly in developing economies like South Africa, are in their infancy. Presently, the only available data source for corporate biodiversity disclosure for listed firms in South Africa is the one compiled by the NBBN (developed by Endangered Wildlife Trust), which commenced in 2018. This study follows the Friedman *et al*. (2022) and utilizes the NBBN biodiversity disclosure index to capture the cross-section of biodiversity disclosure levels across South African firms.

The biodiversity disclosure index is constructed from eight closed-ended questions that collectively assess a firm's engagement with biodiversity issues. The questions are designed to capture different aspects of biodiversity disclosure, reflecting both the strategic intentions and

**Table 1.** Data cleaning and sample distribution by sector

| Sectors | Initial sample | Excluded/ Missing | Final sample | Proportion % |
|---|---|---|---|---|
| Basic materials | 212 | 100 | 112 | 11 |
| Consumer Discretionary | 112 | 12 | 100 | 9.8 |
| Consumer Staples | 128 | 28 | 100 | 9.8 |
| Energy | 28 | 12 | 16 | 1.6 |
| Financials | 252 | 56 | 196 | 19.3 |
| Health care | 36 | 4 | 32 | 3.1 |
| Industrials | 212 | 28 | 184 | 18.1 |
| Real Estate | 220 | 40 | 180 | 17.7 |
| Technology | 68 | 12 | 56 | 5.5 |
| Telecommunication | 40 | 0 | 40 | 3.9 |
| Total | 1,308 | 292 | 1,016 | 100 |

**Source(s):** Authors' own work

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the technical capacities of firms in relation to biodiversity management. The questions cover the following areas: the existence of a biodiversity policy (Q1); identification of the firm's biodiversity dependencies and impacts (Q2); whether these dependencies and impacts are measured and valued (Q3, Q4); the presence of a biodiversity strategy, targets, and associated key performance indicators (Q5); the development of a biodiversity action plan (Q6); the disclosure of biodiversity risks and performance (Q7); and the implementation of a biodiversity monitoring system for continuous improvement (Q8). These questions are grounded in the principles of the impact mitigation hierarchy and the no-net-loss or net-gain approach to biodiversity values.

These eight items can be classified into three broad dimensions of disclosure. First, strategic and policy-level disclosures include the firm's biodiversity policy (Q1), strategy and targets (Q5), and action plans (Q6). These items reflect a firm's high-level commitments and governance posture toward biodiversity. Second, technical measurement and valuation cover more complex and data-intensive disclosures, such as the measurement of biodiversity impacts (Q3), valuation and materiality assessments (Q4), and disclosure of biodiversity risks and performance (Q7). These require scientific input, operational systems, and integration with environmental accounting frameworks. Third, systems and monitoring disclosures include the identification of dependencies and impacts (Q2) and the existence of biodiversity monitoring mechanisms (Q8), reflecting a firm's capacity to track and manage biodiversity performance over time.

Each question is scored on a five-point scale, from 0 (no disclosure) to 4 (comprehensive and detailed disclosure). Scores across the eight questions are aggregated to generate an annual biodiversity disclosure score for each firm, with a maximum possible score of 32. Following the literature, this cumulative score enables us to assess both the extent and quality of biodiversity disclosure on a year-by-year basis (Friedman *et al*., 2022). The full scoring system and coding framework are provided in Appendix 2 (Friedman *et al*., 2022).

Board gender diversity is the main independent variable in the study. It is measured by the proportion of female directors on the board of directors. To test for the critical mass hypothesis (H2), we employ dummy variables to capture the extent of female board representation. Specifically, we compute five measures; "Exactly one female", "Exactly two females", "One or more females", "Two or more females", "Three or more females". If our critical mass arguments hold, we should find results to be strongest in cases of "Three or more females".

The control variables employed in the study are informed by extant studies on environmental and biodiversity reporting literature (Welbeck *et al*., 2017; Carvajal *et al*., 2022; Issa and Zaid, 2023; Dutta and Dutta, 2023). We control for firm characteristics and isolate the effects of gender on the board by also controlling for other governance features. Our firm-level controls include measures of profitability (return on assets), firm size (natural log of total assets), leverage (debt to equity ratio), Tobin's Q (sum of market value of equity plus book value of long-term debt to book value of total assets), Liquidity (current ratio; current assets to current liabilities) and tangible assets (the ratio of fixed assets to total assets). Our board controls include measures of board size (natural log of number of board members), board independence (proportion of independent directors within the board), ethnic diversity (proportion of black directors on the board) and frequency of board meetings (natural log of the number of board meetings).

Data on all the variables are sourced from the firms' annual reports except the biodiversity disclosure score, which is derived from the https://nbbnbdp.org/company-ratings/. The availability of data, therefore, limits the choice of variables we include in the study. The full definition for all our variables is summarized in Appendix 1.

Lastly, we control for industry and year-fixed effects throughout our analysis to account for industry variations and macro-economic and market-wide influences on firms' biodiversity disclosure practices. All our variables are checked for outliers. Our continuous variables are winsorized at the 1st and 99th percentiles to eliminate the influence of outliers.

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## 4. Results and discussion

### *4.1 Descriptive statistics*

Table 2 provides the descriptive statistics for the variables in the study. The average value of the biodiversity disclosure score for the entire sample size is 0.908 on a scale of (0.0–32.0). Meanwhile, the 1st and 99th percentile values of the biodiversity score are 0.00 and 11.00, respectively. Surprisingly, the 75th percentile is zero, suggesting that more than 75% of the firms in the sample do not disclose any information on biodiversity-related issues in their annual report. Figure 1 provides further details on the distribution of biodiversity disclosures across sampled firms. Over 85% of firms recorded a disclosure score of zero in 2018, 80% in 2019, 75% in 2020 and 67% in 2021. This trend captures the growth in biodiversity disclosure practices amongst listed South African firms. Notwithstanding, the data suggest that, despite the requirement for integrated reporting in South Africa, the majority of the sample firms do not provide substantive [2] information on their interaction with biodiversity over the four years examined. This low level of engagement is consistent with the findings of prior studies in other contexts. For instance, Addison *et al*. (2019) and Haque and Jones (2020) document low biodiversity disclosure for UK and European firms, respectively. Similarly, Dutta and Dutta (2023) observe that only a small number of Finnish firms disclose biodiversity-related information.

Given the unique structure of the NBBN survey, it is important to examine whether the NBBN scoring index specifically captures biodiversity disclosure or whether it reflects broader corporate social responsibility (CSR) and sustainability reporting practices—raising potential concerns about measurement validity. To explore this, in Appendix 3, we conduct a comparative analysis of the 2021 integrated reports of the highest- and lowest-scoring firms on the index: Anglo American PLC, which received the highest score of 18, and Mr. Price Group Limited, one of the firms that received a score of zero.

Anglo American PLC, a mining company in the Basic Materials sector, demonstrates a strong commitment to biodiversity, whereas Mr. Price Group Limited, a consumer staples firm, shows minimal engagement based on its 2021 integrated reports. Anglo American has a

**Table 2.** Descriptive statistics

| Variable | Obs | Mean | SD | P1 | P25 | Median | P75 | P99 |
|---|---|---|---|---|---|---|---|---|
| Biodiversity disclosure | 1,016 | 0.908 | 2.377 | 0.000 | 0.000 | 0.000 | 0.000 | 11.000 |
| Gender diversity | 1,016 | 0.243 | 0.141 | 0.000 | 0.143 | 0.250 | 0.333 | 0.600 |
| Female (#) | 1,016 | 2.513 | 1.689 | 0.000 | 1.000 | 2.000 | 4.000 | 7.000 |
| One female | 1,016 | 0.225 | 0.418 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 |
| Two females | 1,016 | 0.219 | 0.414 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 |
| One or more females | 1,016 | 0.907 | 0.290 | 0.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Two or more females | 1,016 | 0.682 | 0.466 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 |
| Three or more females | 1,016 | 0.463 | 0.499 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 |
| Profitability | 1,016 | 0.044 | 0.153 | −0.639 | −0.012 | 0.051 | 0.116 | 0.448 |
| Firm size | 1,016 | 8.992 | 2.247 | 3.881 | 7.488 | 8.885 | 10.319 | 14.648 |
| Leverage | 1,016 | 1.601 | 2.640 | −3.440 | 0.372 | 0.778 | 1.571 | 13.210 |
| Tobin's Q | 1,016 | 1.065 | 0.866 | 0.030 | 0.570 | 0.810 | 1.255 | 4.640 |
| Liquidity | 1,016 | 2.905 | 7.391 | 0.070 | 0.923 | 1.420 | 2.283 | 62.096 |
| Tangible assets | 1,016 | 0.510 | 3.794 | 0.000 | 0.049 | 0.232 | 0.509 | 2.905 |
| Ethnic diversity | 1,016 | 0.379 | 0.240 | 0.000 | 0.200 | 0.375 | 0.545 | 1.000 |
| Board independence | 1,016 | 0.540 | 0.172 | 0.000 | 0.429 | 0.556 | 0.667 | 0.917 |
| Board size (#) | 1,016 | 9.902 | 3.050 | 5.000 | 8.000 | 10.000 | 12.000 | 18.000 |
| Board size | 1,016 | 2.247 | 0.305 | 1.609 | 2.079 | 2.303 | 2.485 | 2.890 |
| Board meetings (#) | 1,016 | 5.895 | 3.411 | 2.000 | 4.000 | 5.000 | 7.000 | 19.000 |
| Board meetings | 1,016 | 1.666 | 0.437 | 0.693 | 1.386 | 1.609 | 1.946 | 2.944 |

**Note(s):** The table presents descriptive statistics of key variables used in the study. Full variable definitions are presented in Appendix 1

**Source(s):** Authors' own work

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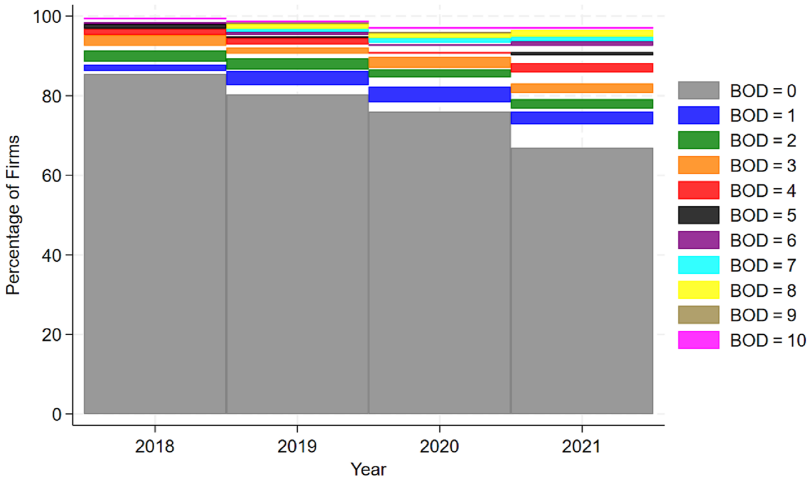


**Figure 1.** Biodiversity reporting across South African firms. Source: Authors' own work

dedicated sustainability committee overseeing environmental and climate strategies, while Mr. Price did not establish such a committee in 2021. Anglo sets out clear biodiversity-related goals, including a 50% reduction in freshwater withdrawal in water-scarce regions by 2030 and the achievement of net-positive biodiversity outcomes. No comparable policy is outlined by Mr. Price. Anglo also presents a strategic biodiversity framework with defined procedures and mitigation plans across the mining lifecycle, which is absent in Mr. Price's disclosures. In addition, Anglo highlights partnerships with NGOs and global bodies, including Fauna and Flora International, and biodiversity is mentioned 29 times in its 2021 report. By contrast, Mr. Price refers to biodiversity only three times and provides no evidence of partnerships or engagement with Nature-related Financial Disclosures (TNFD). Overall, Anglo American's proactive and structured approach is reflected in its high NBBN biodiversity rating, while Mr. Price's limited reporting corresponds with a lower score. Further detail on this assessment is presented in Appendix 3.

The average female representation on the board for our sampled firms 24.3%. The 25th percentile is 14.3%, and the 75% is 33.3%. The median firm has about two female directors on its board. As shown in Figure 2, about 9% of firms have no female director on their board, and about 22.5% of firms have only one female director on their board. Finally, over 46.3% of firms have three or more female directors.

For firm-specific control variables, as seen in Table 2, the average values of profitability, firm size, leverage, Tobin's Q, Liquidity, and tangible assets are 4.4%, 8.992, 1.601, 1.065, 2.905, and 0.510, respectively. Again, there is significant variation in these firm-specific indicators across the sample firms, suggesting a high level of heterogeneity among the JSE firms. For the board characteristics, 37.9% of directors in the average firm are Black, and 54.0% are independent. The median board has about 10 directors in total and holds about seven board meetings each year.

In Table 3, we explore biodiversity disclosures across firms with different levels of board gender diversity using a difference of means test. This should give us preliminary support for our hypotheses. We present results for the subsample of firms with "One or more females", "Two or more females", and "Three or more females" in columns 3 and 4. In columns 1 and 2, we present results for firms that do not have "One or more females", "Two or more females", and "Three or more females" on their boards.

As shown in columns 1 and 2, the 94 firm-year observations with no female board members achieve a mean disclosure score of 0.064. This is much lower than the average 0.994 reported by the

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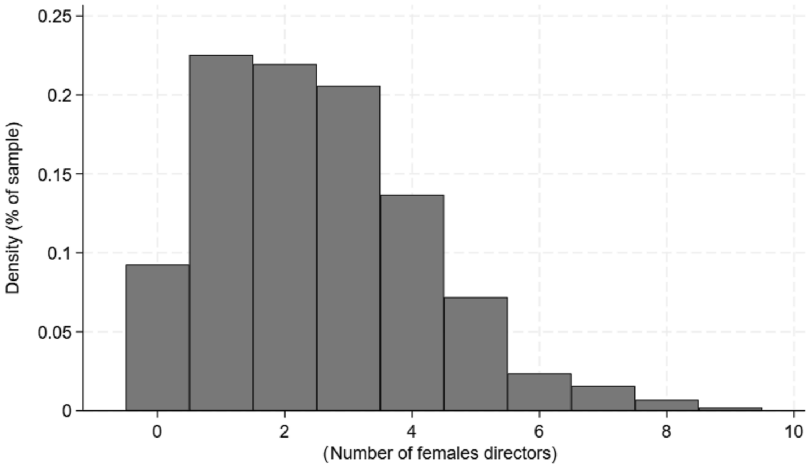


**Figure 2.** Board gender diversity across South African firms. Source: Authors' own work

**Table 3.** Difference of means test: Gender diversity and biodiversity disclosure

| | No | | Yes | | Difference | |
|---|---|---|---|---|---|---|
| Variables | N (1) | Mean disclosure (2) | N (3) | Mean disclosure (4) | Diff. (5) | Significance (6) |
| (1) One or more females | 94 | 0.064 | 922 | 0.994 | −0.930*** | (0.000) |
| (2) Two or more females | 323 | 0.367 | 693 | 1.160 | −0.793*** | (0.000) |
| (3) Three or more females | 546 | 0.490 | 470 | 1.394 | −0.904*** | (0.000) |

**Note(s):** The table explores the difference in mean disclosure between firms with high and low gender diversity. We measure the level of gender diversity, in this case, by the presence of women on the board. That is, the presence of (1) one or more, (2) two or more, and (3) three or more women on the board. Full variable definitions are presented in Appendix 1. ***, **, * indicates statistical significance at the 1, 5 and 10% levels, respectively
**Source(s):** Authors' own work

992 firm-year observations with at least one female on the board. The difference (0.930) is statistically significant at the 1% level. We find similar results in rows 2 and 3, providing preliminary evidence that female board members are associated with improved biodiversity disclosure scores. While this finding is consistent with our hypothesis that gender diversity increases biodiversity disclosure, we interpret it with caution, given the significant differences in sample size.

Before turning our attention to regression analysis, we explore pairwise correlations between our key explanatory variables to allay any concerns about multicollinearity in our dataset. Table 4 presents pairwise correlations. We find that the pairwise correlations amongst our variables are generally lower than acceptable thresholds. The final column of the table also presents variance inflation factors (VIF) for our variables. All our VIFs are lower than 2, suggesting that there are unlikely to be any significant multicollinearity issues impacting our results. We, therefore, turn our attention to multivariate regression analysis to test our hypotheses.

### *4.2 Board gender diversity and biodiversity disclosure*

Our main hypothesis is tested as per Equation (1), and results are presented in Table 5. In column 1 of Table 5, we start by estimating a simple model that includes only our dependent

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**Table 4.** Pairwise correlations

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | VIF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Biodiversity disclosure | 1.000 | | | | | | | | | | | |
| (2) Gender diversity | 0.117* | 1.000 | | | | | | | | | | 1.460 |
| (3) Profitability | 0.128* | 0.097* | 1.000 | | | | | | | | | 1.170 |
| (4) Firm size | 0.271* | 0.272* | 0.067 | 1.000 | | | | | | | | 1.960 |
| (5) Leverage | 0.030 | 0.162* | −0.052 | 0.314* | 1.000 | | | | | | | 1.160 |
| (6) Tobin's Q | 0.096* | 0.088* | 0.292* | 0.017 | −0.062 | 1.000 | | | | | | 1.130 |
| (7) Liquidity | −0.050 | −0.085* | −0.044 | −0.166* | −0.134* | −0.045 | 1.000 | | | | | 1.050 |
| (8) Tangible assets | 0.007 | 0.002 | 0.007 | −0.025 | −0.018 | −0.033 | −0.021 | 1.000 | | | | 1.010 |
| (9) Ethnic diversity | 0.000 | 0.434* | −0.030 | 0.048 | 0.137* | −0.079 | 0.010 | −0.034 | 1.000 | | | 1.360 |
| (10) Board independence | 0.132* | 0.293* | −0.010 | 0.306* | 0.082* | 0.019 | −0.013 | −0.026 | 0.109* | 1.000 | | 1.210 |
| (11) Board size | 0.212* | 0.269* | 0.123* | 0.581* | 0.269* | 0.077 | −0.144* | 0.026 | 0.232* | 0.073 | 1.000 | 1.720 |
| (12) Board meetings | 0.119* | 0.150* | −0.167* | 0.303* | 0.064 | −0.053 | −0.095* | 0.036 | −0.018 | 0.141* | 0.133* | 1.180 |

**Note(s):** The table presents pairwise correlations and variance inflation factors (VIF) for variables later used in our regression analyses. Full variable definitions are presented in Appendix 1. * indicates statistical significance at the 10% level

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**Table 5.** Gender diversity and biodiversity disclosure

| Variables | Dependent variable: Biodiversity disclosure (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Gender diversity | 1.983*** | 2.288*** | 0.823** | 1.142** |
| | (0.474) | (0.439) | (0.414) | (0.486) |
| Profitability | | | 1.489*** | 1.318*** |
| | | | (0.461) | (0.458) |
| Firm size | | | 0.300*** | 0.236*** |
| | | | (0.039) | (0.047) |
| Leverage | | | −0.018 | −0.020 |
| | | | (0.027) | (0.027) |
| Tobin's Q | | | 0.210* | 0.178 |
| | | | (0.108) | (0.108) |
| Liquidity | | | 0.014*** | 0.014** |
| | | | (0.005) | (0.006) |
| Tangible assets | | | 0.004 | 0.003 |
| | | | (0.009) | (0.008) |
| Ethnic diversity | | | | −0.791*** |
| | | | | (0.296) |
| Board independence | | | | 0.893* |
| | | | | (0.504) |
| Board size | | | | 0.699** |
| | | | | (0.314) |
| Board meetings | | | | −0.180 |
| | | | | (0.172) |
| Constant | 0.426*** | 2.650*** | −0.085 | −0.928 |
| | (0.105) | (0.374) | (0.436) | (0.660) |
| Observations | 1,016 | 1,016 | 1,016 | 1,016 |
| *R*-squared | 0.014 | 0.223 | 0.307 | 0.317 |
| Industry FE | No | Yes | Yes | Yes |
| Year FE | No | Yes | Yes | Yes |

**Note(s):** The table explores the relationship between board gender diversity and corporate biodiversity disclosure with and without different control variables. Full variable definitions are presented in Appendix 1. ***, **, * indicates statistical significance at the 1, 5 and 10% levels, respectively

**Source(s):** Authors' own work

(biodiversity disclosure) and independent variables (board gender diversity), with no controls. We then sequentially add different sets of control variables to the model, starting with industry and year-fixed effects in column 2, then firm-level controls in column 3, and finally, governance controls in column 4. Across all columns in Table 5, we find a positive and statistically significant relationship between gender diversity on the board and biodiversity disclosure. Looking at the final column, for example, we find that a unit increase in gender diversity coincides with a 1.142 unit increase in the level of biodiversity disclosure by South African listed firms. These results are statistically significant at the 5% level.

In economic terms, a standard deviation increase in board gender diversity leads to a 16.1% increase in biodiversity disclosure. These results are economically meaningful. They also provide strong evidence of the role of female directors in fostering biodiversity accounting within firms by showing that relative to homogenous boards, firms with more gender-diverse boards provide more information on biodiversity-related practices. These firms are likelier to do so because of their biodiversity protection engagements. Importantly, the results provide empirical support for our first hypothesis (H1).

It is also worth noting that there are statistically significant relationships between some of our control variables and the level of biodiversity disclosure. For example, in Table 5, we find that our measures of profitability, firm size, Tobin's Q, and liquidity have significant and

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positive impacts on biodiversity disclosure. For instance, as shown in column 3, biodiversity disclosure increases by 1.489, 0.300, 0.210, and 0.014 units following a unit rise in profitability, firm size, Tobin's Q, and liquidity, respectively. However, the impact of leverage and tangibility on biodiversity disclosure is statistically insignificant, suggesting that biodiversity disclosure is not affected by the changes in the two control variables. Regarding the board characteristic control variables, board size and board independence have a positive impact on biodiversity disclosure, while the effect of ethnic diversity on biodiversity disclosure is found to be negative. Again, the impact of board meetings on biodiversity disclosure is inconsequential.

### *4.3 Board gender diversity and nature of biodiversity disclosure*

Table 6 presents the results of regressions examining the relationship between board gender diversity and firm-level biodiversity disclosure, using disaggregated measures from the NBBN index (Questions 1 to 8). Overall, the findings provide robust evidence that gender diversity on corporate boards is positively associated with the extent and quality of biodiversity-related reporting. Significant associations are observed for several key dimensions of disclosure. Specifically, gender diversity is positively and significantly related to the presence of a biodiversity policy (Q1), the articulation of biodiversity dependencies and impacts (Q2), the establishment of biodiversity strategies and performance indicators (Q5), and the implementation of biodiversity action plans (Q6). These findings suggest that gender-diverse boards are more likely to promote strategic commitments to biodiversity management and to support the development of internal structures and plans to address biodiversity risks.

There is also weaker but positive evidence that gender diversity contributes to the establishment of biodiversity monitoring systems (Q8), although the relationship is only marginally significant. By contrast, the coefficients for questions relating to the measurement and valuation of biodiversity dependencies and impacts (Q3 and Q4) and for biodiversity risk and performance disclosure (Q7) are not statistically significant. This suggests that while gender-diverse boards are influential in setting the broad strategic direction, their impact may be less immediate or direct when it comes to technically demanding disclosure practices, such as quantification, valuation, and risk modelling.

### *4.4 The role of critical mass*

Our second hypothesis explores whether the documented effect in Table 5 is driven by the presence of a critical mass of female directors on the board. Specifically, we want to explore whether the positive relationship between gender diversity and biodiversity disclosure only persists when there are three or more female directors on the board. To investigate this, we re-estimate Equation (1) by replacing gender diversity with measures of the different levels of representation of women in the boardroom. The outcome from the analysis is presented in Table 7.

In column 1 of Table 7, we assess the impact of having "Exactly one female" on the board on biodiversity disclosure. In column 2, we explore the impact of having "Exactly two females". In columns 3 to 5, we consider the effect of having "One or more females", "Two or more females", and "Three or more females" on the boards, respectively. As in column 1, we find that having exactly one woman on the board is *negatively* associated with biodiversity disclosure (significant at the 5% level). The effect ceases to be statistically significant when there are exactly two females on the board. We find that the effect becomes positive and significant (at the 10% level) when firms have two or more women on their boards. Ultimately, the effect of gender diversity on biodiversity disclosure is positive and statistically significant at the 1% level when firms have three or more women on their boards. These results provide strong support for our second hypothesis (H2) by showing that the presence of a critical mass is essential for women on the board to influence biodiversity disclosure.

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**Table 6.** Gender diversity and biodiversity disclosure: NBBN Q1- Q8

| | Dependent variable: NBBN biodiversity disclosure questions (Q1-Q8) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 |
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Gender diversity | 0.338** | 0.306** | −0.033 | 0.032 | 0.155** | 0.185** | 0.113 | 0.128* |
| | (0.153) | (0.122) | (0.063) | (0.049) | (0.072) | (0.082) | (0.082) | (0.073) |
| Profitability | 0.003** | 0.002** | 0.001*** | 0.001* | 0.002* | 0.002*** | 0.000 | 0.001 |
| | (0.001) | (0.001) | (0.000) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) |
| Firm size | 0.052*** | 0.048*** | 0.006* | 0.002 | 0.028*** | 0.035*** | 0.022*** | 0.038*** |
| | (0.014) | (0.011) | (0.004) | (0.003) | (0.008) | (0.008) | (0.007) | (0.008) |
| Leverage | −0.009 | 0.004 | −0.000 | −0.004 | −0.007** | −0.008* | 0.008 | −0.004 |
| | (0.007) | (0.007) | (0.003) | (0.003) | (0.003) | (0.005) | (0.006) | (0.005) |
| Tobin's Q | 0.040 | 0.029 | 0.011 | −0.008 | 0.030 | 0.020 | 0.019 | 0.031* |
| | (0.027) | (0.024) | (0.010) | (0.007) | (0.021) | (0.016) | (0.016) | (0.019) |
| Liquidity | 0.006** | 0.006* | 0.001 | −0.000 | 0.001* | 0.002*** | 0.001* | 0.002** |
| | (0.002) | (0.003) | (0.000) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) |
| Tangible assets | −0.000 | −0.000 | −0.000 | 0.000 | 0.001 | −0.000 | 0.000 | 0.001 |
| | (0.002) | (0.002) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Ethnic diversity | −0.202** | −0.157** | 0.049 | −0.039 | −0.109*** | −0.151*** | −0.107** | −0.163*** |
| | (0.100) | (0.078) | (0.041) | (0.026) | (0.037) | (0.050) | (0.050) | (0.049) |
| Board independence | 0.344*** | 0.135 | 0.047 | 0.092** | −0.003 | 0.194*** | 0.157* | 0.079 |
| | (0.133) | (0.119) | (0.056) | (0.044) | (0.083) | (0.074) | (0.095) | (0.094) |
| Board size | 0.257*** | 0.118 | 0.018 | 0.051* | 0.027 | 0.097* | 0.082 | 0.075 |
| | (0.091) | (0.079) | (0.029) | (0.027) | (0.035) | (0.052) | (0.060) | (0.063) |
| Board meetings | −0.063 | −0.021 | 0.026 | 0.013 | −0.055** | −0.045 | −0.038 | −0.069* |
| | (0.054) | (0.048) | (0.026) | (0.025) | (0.027) | (0.037) | (0.038) | (0.036) |
| Constant | −0.348* | −0.271 | −0.014 | −0.006 | 0.086 | −0.003 | −0.108 | −0.108 |
| | (0.184) | (0.172) | (0.063) | (0.059) | (0.089) | (0.114) | (0.129) | (0.137) |
| Observations | 981 | 981 | 981 | 981 | 981 | 981 | 981 | 981 |
| *R*-squared | 0.275 | 0.254 | 0.136 | 0.148 | 0.174 | 0.309 | 0.172 | 0.218 |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

**Note(s):** The table explores the relationship between board gender diversity and various aspects of corporate biodiversity disclosure as captured by the NBBN index. Q1 to Q8 captures a firm's scores across the following areas. (Q1) "What is the biodiversity policy of the company?" (Q2) "What are the biodiversity dependencies and impacts of the company?" (Q3) "Does the company measure its biodiversity dependencies and impacts?" (Q4) "Does the company value its biodiversity dependencies and impacts? What are the most material ones?" (Q5) "Does the company have a biodiversity strategy, biodiversity targets, and associated key performance indicators (KPIs)?" (Q6) "Does the company have a biodiversity action plan?" (Q7)"Does the company disclose its biodiversity risks and performance?" (Q8)"Does the company have a biodiversity monitoring system in place for continuous improvements?" Full variable definitions are presented in Appendix 1. ***, **, * indicates statistical significance at the 1, 5 and 10% levels, respectively

**Source(s):** Authors' own work

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**Table 7.** Gender diversity and biodiversity disclosure: Critical mass

| Variables | Dependent variable: Biodiversity disclosure (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Exactly one female | −0.274** | | | | |
| | (0.133) | | | | |
| Exactly two females | | −0.175 | | | |
| | | (0.139) | | | |
| One or more females | | | −0.087 | | |
| | | | (0.156) | | |
| Two or more females | | | | 0.256* | |
| | | | | (0.141) | |
| Three or more females | | | | | 0.455*** |
| | | | | | (0.162) |
| Profitability | 1.376*** | 1.395*** | 1.389*** | 1.355*** | 1.371*** |
| | (0.468) | (0.466) | (0.467) | (0.465) | (0.465) |
| Firm size | 0.243*** | 0.247*** | 0.248*** | 0.238*** | 0.232*** |
| | (0.048) | (0.049) | (0.049) | (0.048) | (0.048) |
| Leverage | −0.018 | −0.017 | −0.018 | −0.017 | −0.016 |
| | (0.027) | (0.027) | (0.027) | (0.027) | (0.027) |
| Tobin's Q | 0.187* | 0.199* | 0.197* | 0.184* | 0.182* |
| | (0.109) | (0.109) | (0.109) | (0.109) | (0.108) |
| Liquidity | 0.013** | 0.013** | 0.013** | 0.014** | 0.013** |
| | (0.006) | (0.006) | (0.006) | (0.006) | (0.006) |
| Tangible assets | 0.003 | 0.003 | 0.003 | 0.003 | 0.002 |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) |
| Ethnic diversity | −0.585** | −0.513* | −0.481* | −0.643** | −0.779*** |
| | (0.275) | (0.269) | (0.275) | (0.288) | (0.292) |
| Board independence | 0.995** | 1.032** | 1.072** | 0.964* | 0.817 |
| | (0.495) | (0.492) | (0.491) | (0.494) | (0.498) |
| Board size | 0.639** | 0.702** | 0.729** | 0.588* | 0.472 |
| | (0.316) | (0.313) | (0.322) | (0.327) | (0.324) |
| Board meetings | −0.175 | −0.144 | −0.148 | −0.168 | −0.180 |
| | (0.177) | (0.175) | (0.175) | (0.174) | (0.174) |
| Constant | −0.703 | −1.047 | −1.110* | −0.754 | −0.286 |
| | (0.699) | (0.643) | (0.649) | (0.715) | (0.697) |
| Observations | 1,016 | 1,016 | 1,016 | 1,016 | 1,016 |
| *R*-squared | 0.316 | 0.315 | 0.315 | 0.316 | 0.320 |
| Industry FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |

**Note(s):** The table explores the relationship between board gender diversity and corporate biodiversity disclosure for different levels of gender diversity (i.e. the number of females on the board). Full variable definitions are presented in Appendix 1. ***, **, * indicates statistical significance at the 1, 5 and 10% levels, respectively

Source(s): Authors' own work

### *4.5 Additional analysis and robustness checks*

We conduct several further analyses to strengthen our inferences in Table 8. Firstly, we consider the nature of the firms' industry, focussing on whether the firm belongs to an environmentally sensitive or non-sensitive industry. This is motivated by research suggesting that the industry a firm belongs to might influence its behaviour and decisions on environmental-related activities, including biodiversity reporting (Ofoegbu *et al.*, 2018). Environmentally sensitive industries are those whose activities have a direct bearing on biodiversity in the environment, such as industries involved in mining and construction. Constituent firms will likely naturally disclose biodiversity information, irrespective of gender diversity, as their operations directly impact the environment. Non-sensitive firms may face less pressure for biodiversity disclosure from their stakeholders.

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**Table 8.** Robustness checks

| Variables | All (1) | (2) | Ex financials (3) | (4) | Probit regression (5) | (6) | Panel FE regression (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Gender diversity | 0.533 | | 1.024* | | 0.644 | | 1.446** | |
| | (0.481) | | (0.595) | | (0.459) | | (0.679) | |
| Three or more females | | 0.199 | | 0.463** | | 0.317** | | 0.375** |
| | | (0.163) | | (0.192) | | (0.137) | | (0.179) |
| Sensitive | 2.590*** | 2.662*** | | | | | | |
| | (0.384) | (0.366) | | | | | | |
| Gender diversity#Sensitive | 2.203* | | | | | | | |
| | (1.124) | | | | | | | |
| Three or more females#Sensitive | | 0.908*** | | | | | | |
| | | (0.343) | | | | | | |
| Profitability | 0.013*** | 0.013*** | 0.019*** | 0.019*** | 0.007 | 0.008 | 0.008* | 0.008* |
| | (0.005) | (0.005) | (0.006) | (0.006) | (0.005) | (0.005) | (0.004) | (0.004) |
| Firm size | 0.235*** | 0.235*** | 0.313*** | 0.310*** | 0.128*** | 0.124*** | −0.343*** | −0.341*** |
| | (0.047) | (0.047) | (0.060) | (0.060) | (0.036) | (0.036) | (0.090) | (0.090) |
| Leverage | −0.017 | −0.011 | 0.026 | 0.030 | 0.039* | 0.042** | 0.030 | 0.035 |
| | (0.027) | (0.026) | (0.044) | (0.044) | (0.020) | (0.020) | (0.032) | (0.032) |
| Tobin's Q | 0.186* | 0.201* | 0.108 | 0.108 | −0.033 | −0.036 | −0.011 | −0.003 |
| | (0.107) | (0.107) | (0.115) | (0.115) | (0.073) | (0.073) | (0.132) | (0.132) |
| Liquidity | 0.015** | 0.014** | −0.005 | −0.006 | 0.012 | 0.012 | −0.003 | −0.003 |
| | (0.006) | (0.006) | (0.008) | (0.007) | (0.008) | (0.008) | (0.009) | (0.009) |
| Tangible assets | 0.003 | 0.003 | 0.002 | 0.001 | 0.004 | 0.003 | −0.009 | −0.009 |
| | (0.008) | (0.007) | (0.007) | (0.008) | (0.010) | (0.010) | (0.012) | (0.012) |
| Ethnic diversity | −0.803*** | −0.742*** | −0.854** | −0.875** | 0.181 | 0.135 | −0.759 | −0.550 |
| | (0.294) | (0.287) | (0.339) | (0.340) | (0.271) | (0.263) | (0.543) | (0.529) |
| Board independence | 0.814 | 0.672 | 1.092* | 0.974 | 1.240*** | 1.169*** | −0.118 | −0.132 |
| | (0.504) | (0.493) | (0.650) | (0.640) | (0.351) | (0.350) | (0.468) | (0.468) |
| Board size | 0.664** | 0.418 | 0.981** | 0.737* | 0.719*** | 0.529** | 0.204 | 0.072 |
| | (0.315) | (0.320) | (0.381) | (0.396) | (0.229) | (0.243) | (0.333) | (0.343) |

(*continued*)

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**Table 8.** Continued

| Variables | All | | Ex financials | | Probit regression | | Panel FE regression | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Board meetings | −0.228 | −0.231 | −0.286 | −0.292 | 0.050 | 0.051 | 0.226 | 0.256 |
| | (0.204) | (0.205) | (0.232) | (0.233) | (0.151) | (0.151) | (0.220) | (0.219) |
| Constant | −3.602*** | −2.942*** | −2.104** | −1.416 | −3.649*** | −3.104*** | 2.673** | 2.986** |
| | (0.663) | (0.690) | (0.819) | (0.863) | (0.522) | (0.581) | (1.209) | (1.217) |
| Observations | 1,016 | 1,016 | 821 | 821 | 1,016 | 1,016 | 1,016 | 1,016 |
| *R*-squared | 0.322 | 0.328 | 0.337 | 0.339 | | | 0.117 | 0.117 |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | No | No | No | No | No | No | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

**Note(s):** The table explores the relationship between board gender diversity and corporate biodiversity disclosure for robustness. Columns 1 and 2 explore the moderating effect of environmental sensitivity. Columns 3 and 4 estimate results after excluding financial firms. Columns 5 and 6 redefine biodiversity disclosure as a dummy variable capturing the presence or absence of such disclosure. Columns 7 and 8 present results using panel fixed effect estimators. *R*-squared values for probit regressions are pseudo-*r*-squares. Full variable definitions are presented in Appendix 1. ***, **, * indicates statistical significance at the 1, 5 and 10% levels, respectively

**Source(s):** Authors' own work



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In column 1 of Table 8, we explore whether the documented effect of gender diversity on biodiversity disclosure is more pronounced for environmentally sensitive firms using moderation analysis. The moderation effect of "Sensitive" — a dummy variable that takes a value of one for firms in environmentally-sensitive industries and zero, otherwise — is positive and statistically significant at the 5% level. Additionally, the coefficient of "Sensitive" is positive and significant, consistent with the fact that these firms naturally pay more attention to biodiversity due to the nature of their operations. Taken together, these results suggest that women play a critical role in enhancing biodiversity protection and preservation, particularly for firms in environmentally sensitive industries.

As earlier reported (Table 1), over 20% of firms in our sample are financial firms — firms subject to unique reporting requirements. To ensure that our results are not driven by these firms, in column 2 of Table 8, we re-estimate our baseline results after excluding financial firms from our sample. We find that our baseline results remain positive and significant at the 10% level, providing evidence that our findings are robust to their exclusion.

The distribution of our biodiversity disclosure data is heavily skewed to the left. Specifically, as shown in Table 2, over 75% of firms in our sample do not disclose biodiversity information or achieve a biodiversity disclosure score of zero. To address concerns around the level of skewness in the dependent variable in a meaningful way, we estimate probit regressions. Specifically, we explore whether the probability or likelihood of a biodiversity disclosure (i.e. a biodiversity score greater than zero) is explained by board gender diversity. Our dependent variable for this probit regression analysis is a dummy variable that takes a value of one if a firm has a score greater than zero, and a value of zero otherwise. In column 3 Table 8, we find that board gender diversity is positively related to the likelihood of a firm achieving a biodiversity disclosure index of one or more, but the results are not significant at the 10% level. However, when considering whether a critical mass of female representation impacts the likelihood of biodiversity disclosure (i.e. column 4), we find positive results significant at the 5%, level. This suggests that a critical mass of female representation increases the likelihood of firms making biodiversity disclosures.

*4.6 Biodiversity disclosure versus environmental performance*

A key concern in interpreting the link between board gender diversity and biodiversity disclosure is that the latter often forms part of broader CSR, ESG, or sustainability reporting frameworks (Jones and Solomon, 2013). As such, observed effects may reflect general environmental responsibility rather than a distinct focus on biodiversity. To address this potential construct validity issue, we implement two strategies to assess whether gender diversity influences biodiversity disclosure independently of overall environmental performance.

First, Column 1 of Table 9 includes a control for firms' environmental performance using the Refinitiv E Score. Gender diversity remains positively associated with biodiversity disclosure and statistically significant at the 10% level ($\beta = 1.902,\ p < 0.10$), suggesting an effect beyond general environmental performance. The E Score itself is also significant ($\beta = 0.030,\ p < 0.01$), confirming its role as a relevant control. In other words, among firms with similar E Scores, those with more gender-diverse boards disclose more on biodiversity.

Second, in Column 2, we orthogonalize the biodiversity measure by regressing it on E Score and using the residuals—capturing variation in biodiversity disclosure not explained by environmental performance—as the dependent variable. Gender diversity remains positively associated and significant at the 5% level, reinforcing that its effect is not merely an artefact of broader ESG behaviour.

Columns 3 and 4 test whether this effect depends on environmental performance levels through interaction terms. Column 3 interacts gender diversity with a high E Score dummy (above median), while Column 4 uses a continuous E Score interaction. In both cases, the interaction terms are positive and significant, indicating that gender diversity has a stronger

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**Table 9.** The confounding effect of ESG (environmental) performance

| Variables | Dependent variable: Biodiversity disclosure<br>E score control<br>(1) | Orthogonalized<br>(2) | E score interaction<br>(3) | (4) |
|---|---|---|---|---|
| High E Score (dummy)#Gender diversity | | | 4.083* | |
| | | | (2.106) | |
| Gender diversity #E Score | | | | 0.100* |
| | | | | (0.051) |
| Gender diversity | 1.902* | 2.051** | 0.455 | −1.695 |
| | (1.032) | (1.037) | (0.944) | (1.617) |
| High E Score (dummy) | | | −0.019 | |
| | | | (0.651) | |
| E Score | 0.030*** | | | 0.002 |
| | (0.006) | | | (0.015) |
| Profitability | 0.025* | 0.023* | 0.027** | 0.026** |
| | (0.013) | (0.013) | (0.013) | (0.013) |
| Firm size | 0.181* | 0.086 | 0.244** | 0.184* |
| | (0.106) | (0.101) | (0.107) | (0.106) |
| Leverage | −0.047 | −0.074* | −0.026 | −0.046 |
| | (0.044) | (0.043) | (0.043) | (0.044) |
| Tobin's Q | 0.451** | 0.412* | 0.514** | 0.428* |
| | (0.225) | (0.232) | (0.234) | (0.227) |
| Liquidity | 0.010 | 0.012 | 0.005 | 0.002 |
| | (0.013) | (0.014) | (0.013) | (0.013) |
| Tangible assets | 0.003 | 0.003 | 0.005 | 0.003 |
| | (0.006) | (0.006) | (0.007) | (0.007) |
| Ethnic diversity | −1.434** | −1.527** | −1.339* | −1.334* |
| | (0.690) | (0.700) | (0.685) | (0.693) |
| Board independence | −0.212 | −0.649 | −0.152 | −0.240 |
| | (1.022) | (0.947) | (1.031) | (1.016) |
| Board size | 0.071 | −0.207 | 0.415 | 0.251 |
| | (0.612) | (0.599) | (0.569) | (0.597) |
| Board meetings | −0.425 | −0.605 | −0.228 | −0.345 |
| | (0.481) | (0.478) | (0.467) | (0.474) |
| Constant | 1.203 | 3.098** | 0.461 | 1.583 |
| | (1.413) | (1.295) | (1.356) | (1.467) |
| Observations | 438 | 438 | 438 | 438 |
| *R*-squared | 0.422 | 0.307 | 0.421 | 0.429 |
| Industry FE | No | No | No | No |
| Year FE | No | No | No | No |

**Note(s):** This table presents robustness checks assessing whether the effect of board gender diversity on biodiversity disclosure is distinct from broader environmental performance. Column (1) includes the firm's environmental performance (E Score) from Refinitiv as a control variable. Column (2) uses an orthogonalized biodiversity disclosure measure, derived by regressing biodiversity disclosure on E Score and using the residuals as the dependent variable. Columns (3) and (4) test for interaction effects between gender diversity and environmental performance. Full variable definitions are presented in Appendix 1. ***, **, * indicates statistical significance at the 1, 5 and 10% levels, respectively

**Source(s):** Authors' own work

impact on biodiversity disclosure in firms with higher environmental performance. This suggests that gender-diverse boards are more effective in firms where environmental systems and awareness are already in place.

Together, these findings offer robust evidence that gender diversity influences biodiversity disclosure in ways not fully explained by broader ESG or environmental performance, and that this effect is amplified in environmentally proactive firms.

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*4.7 Endogeneity: omitted variable and selection bias*

In the remainder of our analysis, we focus on addressing the problem of endogeneity. To this point, we have provided evidence that board gender diversity is positive and significantly associated with firms' biodiversity disclosure. However, evidence of association does not imply causation or causality. This is particularly the case here because our empirical analysis is prone to omitted variable bias and selection bias.

In terms of omitted variable bias, our models control for several firm and governance factors that may affect biodiversity disclosures. However, our measure of board gender diversity might be correlated to other unobservable factors that may also drive biodiversity disclosure. One such factor is corporate culture. To address the problem of omitted variables in our analysis, we re-estimate our model using a panel regression with firm and year-fixed effects. We present the results with robust standard errors in column 5 of Table 8. In addition, given the small size and potential cross-sectional dependence in our sample, we report results using Driscoll-Kraay standard errors in column 6. In the two cases, we find that our results are qualitatively similar and support the prediction of our main hypothesis. Having partly addressed omitted variable bias, we turn our attention to, perhaps, the most important source of endogeneity in our analysis — selection bias.

Selection bias arises in our analysis as female directors are not randomly allocated to firms. Firms with certain characteristics are more likely to recruit female directors, and female directors are likelier to seek appointments at firms with specific characteristics. For example, female directors may be more attracted to firms with generous maternity pay, work-life balance, and family-oriented policies. This non-random distribution of female directors across the sample may induce selection bias that hinders inferences around causality.

We address selection bias using two complementary matching techniques: propensity score matching and entropy balancing. Propensity score matching is well-suited for mitigating selection bias because it creates comparable treatment and control groups by matching units with similar propensity scores, thereby balancing the distribution of observed covariates and reducing confounding (Brooks, 2014). By condensing multiple covariates into a single score, propensity score matching simplifies the matching process and remains practical even when many covariates are included. This approach helps approximate the conditions of a randomized experiment, allowing the treatment effect to be estimated more credibly. Nevertheless, propensity score matching only adjusts for observable factors and cannot eliminate bias from unobserved confounders, though it remains widely used in accounting research (Tunyi *et al*., 2025). Alternative approaches, such as the Heckman selection model, are particularly useful when the sample is not randomly drawn from the population. In our case, the sample includes all listed South African firms for which data are available and, therefore, is less prone to self-selection concerns.

To operationalize the matching procedure, we create a treatment variable, "Treated", which identifies firms with three or more female directors on their board (critical mass). The remainder of the firms are considered as the "Control" group. This gives us 470 treated firms and 546 control firms. Using propensity score matching, we match our treated firms to control firms on eight characteristics, including profitability, firm size, leverage, Tobin's Q, liquidity, ethnic diversity, board independence, and board meetings. We use a one-to-one matching algorithm with no replacement. We achieved a match of 97 treated firms matched to 97 control firms (194 firm-year observations). The propensity score diagnostics (Rubin's B and R) suggest that the matching procedure significantly reduces mean and median bias between the treated and control firms in the matched group. As shown in Panel A2 of Table 10, the matched sample is more homogeneous in terms of the distribution of the eight variables. We use this matched sample to re-estimate our results in columns 1 and 2, panel C of Table 10.

In untabulated results, we also explore an alternative matching strategy, where we match treated firms to up to 5 of their nearest neighbours based on a caliper of 0.1 (i.e. absolute difference in propensity scores of less than 0.1). This approach aims to enhance match quality

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**Table 10.** Addressing endogeneity from selection bias

Panel A: Propensity score matching diagnostics (1-to-1 match)

| Variable | Mean | | Bias | | Difference | V(T)/ V(C) |
|---|---|---|---|---|---|---|
| Variables | Treated (1) | Control (2) | %Bias (3) | % Reduction (4) | *p*-value (5) | (6) |
| *Panel A1: Unmatched* | | | | | | |
| Profitability | 0.057 | 0.033 | 15.800 | | 0.013** | 0.55* |
| Firm size | 10.017 | 8.110 | 93.400 | | 0.000*** | 1.15 |
| Leverage | 2.112 | 1.160 | 35.900 | | 0.000*** | 3.10* |
| Tobin's Q | 1.139 | 1.002 | 15.800 | | 0.012** | 1.05 |
| Liquidity | 2.332 | 3.398 | −14.600 | | 0.022** | 0.45* |
| Ethnic diversity | 0.476 | 0.295 | 82.100 | | 0.000*** | 0.81* |
| Board independence | 0.595 | 0.493 | 62.300 | | 0.000*** | 0.93 |
| Board meetings | 6.251 | 5.588 | 19.600 | | 0.002*** | 0.78* |
| *Panel A2: matched* | | | | | | |
| Profitability | 0.055 | 0.055 | 0.100 | 99.700 | 0.993 | 0.92 |
| Firm size | 9.739 | 9.526 | 10.400 | 88.800 | 0.102 | 0.95 |
| Leverage | 1.876 | 2.143 | −10.100 | 72.000 | 0.158 | 1.37* |
| Tobin's Q | 1.138 | 1.097 | 4.700 | 70.100 | 0.504 | 0.81* |
| Liquidity | 2.388 | 2.298 | 1.200 | 91.500 | 0.814 | 1.2 |
| Ethnic diversity | 0.464 | 0.503 | −17.500 | 78.600 | 0.017** | 0.59* |
| Board independence | 0.585 | 0.563 | 13.000 | 79.100 | 0.051* | 1.03 |
| Board meetings | 6.151 | 6.026 | 3.700 | 81.100 | 0.553 | 1.09 |

Panel B: Sample moments before and after entropy balancing

| | Treatment group (three or more females) | | | | Control group (less than three females) | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Obs | Mean | Variance | Skewness | Obs | Mean | Variance | Skewness |
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *Panel B1: Sample moments before entropy balancing* | | | | | | | | |
| Profitability | 470 | 0.057 | 0.016 | −0.385 | 546 | 0.033 | 0.029 | −1.426 |
| Firm size | 470 | 10.020 | 4.459 | 0.457 | 546 | 8.110 | 3.879 | 0.024 |
| Leverage | 470 | 2.112 | 10.620 | 2.139 | 546 | 1.160 | 3.428 | 3.542 |
| Tobin's Q | 470 | 1.139 | 0.765 | 1.856 | 546 | 1.002 | 0.729 | 2.355 |
| Liquidity | 470 | 2.332 | 32.880 | 8.343 | 546 | 3.398 | 72.910 | 5.866 |
| Ethnic diversity | 470 | 0.476 | 0.044 | 0.191 | 546 | 0.295 | 0.054 | 0.721 |
| Board independence | 470 | 0.595 | 0.026 | −0.309 | 546 | 0.493 | 0.028 | −0.368 |
| Board meetings | 470 | 6.251 | 9.988 | 2.903 | 546 | 5.588 | 12.870 | 3.895 |
| *Panel B2: Sample moments after entropy balancing* | | | | | | | | |
| Profitability | 470 | 0.057 | 0.016 | −0.385 | 546 | 0.057 | 0.016 | −0.385 |
| Firm size | 470 | 10.020 | 4.459 | 0.457 | 546 | 10.020 | 4.459 | 0.457 |
| Leverage | 470 | 2.112 | 10.620 | 2.139 | 546 | 2.112 | 10.620 | 2.139 |
| Tobin's Q | 470 | 1.139 | 0.765 | 1.856 | 546 | 1.139 | 0.765 | 1.856 |
| Liquidity | 470 | 2.332 | 32.880 | 8.343 | 546 | 2.332 | 32.890 | 8.342 |
| Ethnic diversity | 470 | 0.476 | 0.044 | 0.191 | 546 | 0.476 | 0.044 | 0.190 |
| Board independence | 470 | 0.595 | 0.026 | −0.309 | 546 | 0.595 | 0.026 | −0.309 |
| Board meetings | 470 | 6.251 | 9.988 | 2.903 | 546 | 6.251 | 9.988 | 2.903 |

(*continued*)

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**Table 10.** Continued

Panel C: Regression results after addressing selection bias

| Variables | Propensity score matching (1) | (2) | Entropy balancing (3) | (4) |
|---|---|---|---|---|
| Gender diversity | 1.947* | | 1.888*** | |
| | (1.039) | | (0.612) | |
| Three or more females | | 0.352* | | 0.611*** |
| | | (0.187) | | (0.161) |
| Profitability | −0.000 | 0.018** | 0.016* | 0.016* |
| | (0.007) | (0.008) | (0.009) | (0.009) |
| Firm size | 0.225* | 0.330*** | 0.390*** | 0.368*** |
| | (0.127) | (0.067) | (0.069) | (0.067) |
| Leverage | 0.154* | 0.008 | −0.044 | −0.037 |
| | (0.087) | (0.035) | (0.037) | (0.036) |
| Tobin's Q | 0.114 | 0.162 | 0.225 | 0.249* |
| | (0.164) | (0.157) | (0.153) | (0.151) |
| Liquidity | 0.017 | 0.028*** | 0.029*** | 0.027*** |
| | (0.011) | (0.010) | (0.008) | (0.008) |
| Ethnic diversity | −1.504** | −0.932** | −0.626 | −0.589 |
| | (0.666) | (0.436) | (0.504) | (0.495) |
| Board independence | −0.408 | 0.099 | −0.007 | 0.086 |
| | (1.147) | (0.804) | (0.739) | (0.730) |
| Board meetings | 0.053 | −0.474 | −0.515 | −0.492 |
| | (0.075) | (0.326) | (0.336) | (0.337) |
| Constant | 0.390 | 1.661* | 0.342 | 0.681 |
| | (1.137) | (0.964) | (1.039) | (1.005) |
| Observations | 194 | 614 | 1,016 | 1,016 |
| *R*-squared | 0.289 | 0.368 | 0.389 | 0.394 |
| Industry FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |

**Note(s):** Panel A of the table presents sample moments (mean) of treated and control firms before and after propensity score matching. Panel B presents sample moments (mean, variance and skewness) before and after entropy balancing. Panel C explores the relationship between board gender diversity and corporate biodiversity using a propensity score-matched sample in columns 1 and 2 and an entropy-balanced sample in columns 3 and 4. Full variable definitions are presented in Appendix 1. ***, **, * indicates statistical significance at the 1, 5 and 10% levels, respectively

**Source(s):** Authors' own work

while maintaining a reasonable sample size and minimizing potential bias resulting from poor matches.

The main issue with the propensity score matching approach is the significant loss of data from 1,016 to 194 firm-year observations (column 1, panel C of Table 10) and 1,016 to 614 observations (column 2). Our second matching strategy, entropy balancing, allows us to homogenize the treated and control groups without losing data. Specifically, we deploy this technique to re-weight the control group so that its distributional properties are equivalent to those of the treated group across three important moments: the mean, standard deviation, and skewness. Panel B1 (B2) of Table 10 presents the distributional properties of the treatment and control group before (after) entropy balancing. As shown in panel B2, the characteristics of the treated and control groups are virtually similar after balancing. We then use this balanced sample to re-run our regressions.

Panel C of Table 8, presents results of test of H1 following propensity score matching (columns 1 and 2) and entropy balancing (columns 3 and 4). In all cases, we find that our results hold. Our results for gender diversity in column 1 (based on a small matched sample of 194 observations) are statistically significant at the 10% level. Similarly, our results for critical

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mass, based on a larger sample of 786 observations, are also significant at the 10% level. The results from deploying entropy balancing in columns 3 and 4 (based on the full sample) are significant at the 1% level. Taken together, these results provide strong support for a causal relationship between board gender diversity (H1), critical mass (H2), and biodiversity disclosures.

## 5. Discussion and conclusion

### *5.1 Summary of findings*

The potential economic and governance benefits of women in upper managerial positions continue to be a central focus of global corporate governance discourse. In response, several countries, including Norway and Spain, have implemented minimum thresholds for women's representation on corporate boards (Tunyi *et al*., 2023; Ferrary, 2024). Building on this context, the present study examines the role of gender diversity in shaping biodiversity disclosure practices in an emerging market setting—South Africa.

Consistent with earlier findings on biodiversity disclosure, the overall performance of firms listed on the Johannesburg Stock Exchange (JSE) remains low, with an average biodiversity disclosure score of 0.908 on a scale of 0–32. Notably, over 75% of the sampled firms provided no information on their biodiversity-related activities during the study period. However, our year-by-year analysis reveals a consistent improvement in the quantity of biodiversity-related disclosures by South African firms between 2018 and 2021, indicating growing awareness or external pressure for enhanced environmental accountability.

The main findings of this study strongly confirm that board gender diversity enhances biodiversity disclosure among listed firms in South Africa. This positive effect holds across the overall sample, including non-financial firms, and is more pronounced in environmentally sensitive industries. Thus, the study recognizes female board representation as a significant predictor of biodiversity disclosure. These results align with prior studies that find gender-diverse boards improve sustainability outcomes (Baalouch *et al*., 2019; Buallay and Alhalwachi, 2022; Carvajal *et al*., 2022; Haque and Jones, 2020; Velte, 2023; Issa and Zaid, 2023), although they contrast with Hambali and Adhariani (2024), who find no significant effect of gender diversity on biodiversity disclosure across 27 countries. Taken together, our findings support Hypothesis H1, that board gender diversity positively impacts the disclosure of information on biodiversity.

Our findings also provide strong support for the critical mass hypothesis (H2). Specifically, the relationship between female representation and biodiversity disclosure is only evident when there are three or more women on the board. This supports the view that a critical mass of female directors is necessary for women to exert meaningful influence on board decisions related to environmental issues such as biodiversity disclosure. These findings reinforce earlier evidence (De Masi *et al*., 2021; Tunyi *et al*., 2023; García-Meca *et al*., 2024) and support the idea that female directors act in the interest of stakeholders, particularly those concerned with environmental protection. As such, increasing female representation in the upper echelons of South African firms may promote greater compliance with biodiversity-related expectations and strengthen environmental accountability.

Importantly, our dataset enables a more nuanced analysis of how board gender diversity influences different aspects of biodiversity disclosure. We find that gender-diverse boards are more likely to support strategic and governance-related dimensions of biodiversity disclosure, including the articulation of biodiversity policies, the setting of strategic targets, the development of action plans, and the implementation of monitoring systems. These results reinforce arguments from resource-based and legitimacy theories, which posit that diverse boards are better positioned to respond to emerging sustainability and biodiversity challenges.

However, we do not find significant effects of board gender diversity on more technical aspects of biodiversity reporting, specifically, Q3 (measurement of biodiversity dependencies and impacts), Q4 (valuation of biodiversity), and Q7 (disclosure of biodiversity risks and

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performance). These elements of the NBBN index are typically data-intensive and require internal systems for environmental accounting, scientific expertise, and integration with risk management frameworks. It is possible that while gender-diverse boards are more inclined to endorse biodiversity strategies, the implementation of detailed measurement and valuation practices depends on other factors such as operational capabilities, technical knowledge, or industry-specific regulatory pressures.

### *5.2 Policy and practice implications*

These findings have several implications for policy, research, and practice. For policymakers and regulators, the results highlight the importance of gender diversity policies, while also pointing to a potential gap between intent and implementation. Board diversity initiatives may need to be complemented with targeted capacity-building efforts to strengthen firms' ability to measure, value, and report biodiversity impacts. This could include mandatory training for directors on biodiversity-related financial risks, clearer disclosure guidelines, and sector-specific reporting frameworks that standardize expectations for biodiversity metrics.

For practitioners, particularly board members and sustainability officers, the findings emphasize the need to pair board-level commitment with internal investments in technical systems and expertise. Gender-diverse boards may catalyze action, but without appropriate infrastructure, firms may fall short in demonstrating performance or managing biodiversity-related risks. Investors and stakeholders should therefore view board diversity as an enabling condition, rather than a guarantee, for comprehensive biodiversity accountability.

### *5.3 Implications for research*

For researchers, our findings underscore the importance of moving beyond aggregate measures of sustainability disclosure to consider the functional heterogeneity of disclosure content. Distinguishing between strategic and technical dimensions of biodiversity disclosure can provide clearer insight into the mechanisms through which corporate governance structures influence sustainability outcomes. For example, while gender diversity may be associated with the adoption of environmental commitments, other governance or organizational features, such as biodiversity committees, dedicated sustainability professionals, or science-based targets, may be necessary to translate commitments into quantified and verifiable disclosures.

### *5.4 Limitations and directions for future research*

Despite the contributions of this study, several limitations remain. First, the analysis focuses solely on the proportion of female directors. Future studies could incorporate other director attributes, such as age, professional background, tenure, and technical expertise, to examine their influence on biodiversity disclosure. Second, while gender diversity on boards is actively and strongly encouraged in South Africa through various corporate governance codes and legislative frameworks, it is not strictly mandated (e.g. through strict quotas). Consequently, as observed in our data, some firms may have female directors for compliance purposes but without empowering them to contribute meaningfully. Future research could explore the conditions under which female directors enhance biodiversity disclosure in such contexts.

### *5.5 Concluding remarks*

Overall, this study highlights both the promise and limits of board gender diversity as a governance mechanism for advancing biodiversity disclosure. While female board representation is positively associated with greater biodiversity transparency—particularly in strategic areas—board composition should be seen as part of a broader organizational and institutional ecosystem required for effective biodiversity stewardship.

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## Appendix 1

**Table A1.** Variable descriptions

| Variables | Description and measurement |
|---|---|
| Biodiversity Disclosure | A measure of the level of biodiversity disclosure by a firm in a particular year. The measure is obtained from National Biodiversity and Business Network Biodiversity Disclosure Project for South African companies (NBBN, 2021), (it ranges between 1.0 and 32.0). The underlying scoring methodology is presented in Appendix 2 |
| Gender diversity | Proportion of female directors to board members |
| Exactly one female | A dummy variable indicating the presence of exactly one woman on the board |
| Exactly two females | A dummy variable indicating the presence of exactly two women on the board |
| One or more females | A dummy variable indicating the presence of one or more women on the board |
| Two or more females | A dummy variable indicating the presence of two or more women on the board |
| Three or more females | A dummy variable indicating the presence of three or more women on the board |
| Profitability | The ratio of profit before tax to total asset. |
| Firm size | The natural logarithm of total assets |
| Leverage | The ratio total debt to total equity |
| Tobin's Q | The sum of the market value of equity and book value of long-term debt to the value of total assets |
| Liquidity | The ratio of current assets to current liabilities |
| Tangibility | The ratio total fixed asset to total asset. |
| Board size | The natural log of the total number of board members |
| Board independence | Proportion of independent non-executive directors to board size |
| Ethnic diversity | Proportion of black directors to board size |
| Board meetings | The natural log of the number of board meetings held in a year |

**Source(s):** Authors' own work

## Appendix 2

**Table A2.** Biodiversity scoring methodology

| Questions | Scores 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Q1 What is the biodiversity policy of the company? | No information | Clear statement that explains the company's interactions with biodiversity | Clear statement that explains the company's interactions with biodiversity and focuses on impact avoidance and/or minimization | Clear statement that explains the company's interactions with biodiversity and focuses on no-net-loss | Clear statement that explains the company's interactions with biodiversity and focuses on no-net-positive impacts |
| Q2 What are the biodiversity dependencies and impacts of the company? | No information | Clear statement that explains the company's direct, material biodiversity impacts | Clear statement that explains the company's direct, material biodiversity dependencies and impacts | Clear statement that explains the company's material direct and indirect (suppliers, clients) biodiversity dependencies and impacts, including throughout its supply chains | Clear statement that explains the company's material direct and indirect biodiversity dependencies and impacts, over the whole life cycle of products or services |

(*continued*)

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**Table A2.** Continued

| Questions | Scores 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Q3 Does the company measure its biodiversity dependencies and impacts? | No information | Quantitative information on the company's direct material biodiversity impacts | Quantitative information on the company's direct material biodiversity dependencies and impact | Quantitative information on the company's material direct and indirect biodiversity dependencies and impacts, including throughout its supply chains | Quantitative information on the company's material direct and indirect over the whole life cycle of products or services |
| Q4 Does the company value its biodiversity dependencies and impacts? What are the most material ones? | No information | Qualitative, quantitative, and/or monetary values of direct material biodiversity impacts | Qualitative, quantitative, and/or monetary values of direct material biodiversity dependencies and impacts | Quantitative information on the company's material direct and indirect biodiversity dependencies and impacts, including throughout its supply chains | Quantitative information on the company's material direct and indirect biodiversity dependencies and impacts, over the whole life cycle of products or services |
| Q5 Does the company have a biodiversity strategy, biodiversity targets and associated key performance indicators (KPI'ss)? | No information | Targets KPIs for at least one step of the impact mitigation hierarchy | Targets and KPIs for all steps of the impact mitigation hierarchy | No-net-loss targets and KPIs | Net positive impact targets and KPIs |
| Q6 Does the company have a biodiversity action plan? | No information | Action plan covers at least one step of the impact mitigation hierarchy for direct, material biodiversity impacts | Action plan covers at least one step of the impact mitigation hierarchy for direct, material biodiversity dependencies and impacts | Action plan covers at least one step of the impact mitigation hierarchy for direct, material biodiversity dependencies and impacts, including throughout its supply chains | Action plan covers at least one step of the impact mitigation hierarchy for direct, material biodiversity dependencies and impacts, over the whole life of products or services |
| Q7 Does the company disclose its biodiversity risks and performance? | No information | Disclosure of the company risks and performance related to direct, material biodiversity impacts | Disclosure of the company risks and performance related to direct, material biodiversity dependencies and impacts | Disclosure of the company risks and performance related to direct, material biodiversity dependencies and impacts, including throughout its supply chains | Disclosure of the company risks and performance related to direct, material biodiversity dependencies and impacts, over the whole life of products or services |
| Q8 Does the company have a biodiversity monitoring system in place for continuous improvements? | No information | Biodiversity performance monitoring system in place for direct, material biodiversity impacts | Biodiversity performance monitoring system in place for direct, material biodiversity dependencies impacts | Biodiversity performance monitoring system in place for direct, material biodiversity dependencies impacts, including throughout its supply chains | Biodiversity performance monitoring system in place for direct, material biodiversity dependencies impacts, over the whole life of products or services |

**Source(s):** Compiled from the National Biodiversity and Business Network (NBBN): https://nbbnbdp.org/company-ratings/

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**Appendix 3**

**Table A3.** NBBN Biodiversity Scoring: A comparison of two cases

| Questions | Anglo American PLC | Mr. Price Group LTD |
|---|---|---|
| Q1 What is the biodiversity policy of the company? | 4 | 0 |
| Q2 What are the biodiversity dependencies and impacts of the company? | 2 | 0 |
| Q3 Does the company measure its biodiversity dependencies and impacts ? | 1 | 0 |
| Q4 Does the company value its biodiversity dependencies and impacts ? What are the most material ones? | 1 | 0 |
| Q5 Does the company have a biodiversity strategy, biodiversity targets and associated KPIs | 4 | 0 |
| Q6 Does the company have a biodiversity action plan? | 2 | 0 |
| Q7 Does the company disclose its biodiversity risks and performance? | 2 | 0 |
| Q8 Does the company have a biodiversity monitoring system in place? | 2 | 0 |
| Total | 18 | 0 |

To allay concerns around measurement error in our study, we manually read through 2021 integrated reports for two companies—one with a high and another with a low biodiversity score—to ascertain that the NBBN index captures biodiversity disclosure rather than general CSR or sustainability disclosures.

(1) The firm with the highest biodiversity score, Anglo American PLC, had a dedicated sustainability committee responsible for overseeing key policies, processes, and strategies aimed at managing climate-related risks and opportunities on behalf of the company. In contrast, Mr. Price Group Limited did not establish a standalone sustainability committee for the 2021 reporting year.

(2) One of the strategic priorities outlined in Anglo American PLC's 2021 annual report is the protection of the natural environment and ecosystem by delivering positive environmental outcomes and addressing global challenges such as climate change. The firm specifically aims to reduce freshwater withdrawal in water-scarce areas by 50% by 2030 and to achieve net-positive biodiversity and conservation outcomes. This indicates the presence of a clear biodiversity-related policy. Conversely, Mr. Price Group Limited does not outline a similar policy on biodiversity or the natural environment, which explains why Anglo American PLC was awarded four (4) points on Q1.

(3) Anglo American PLC's integrated report further indicates its commitment to providing biodiversity frameworks, procedures, and resources to support mitigation across the mining lifecycle. This suggests that the firm has a strategic biodiversity framework and action plan, for which it earned four (4) points and two (2) points on Q5 and Q6, respectively. In contrast, Mr. Price Group Limited does not include any explicit biodiversity policy in its 2021 integrated report, resulting in a score of zero (0) on most of the questions considered.

(4) Anglo American PLC's 2021 report also affirms the company's readiness to collaborate with NGOs, international institutions, and governments to advance its biodiversity agenda and gain expert insight into Nature-related Financial Disclosures (TNFD). Such information is absent from the 2021 integrated report of Mr. Price Group Limited.

(5) Anglo American PLC also partnered with Fauna and Flora International to support regional initiatives aimed at protecting and enhancing the environment.

(6) Finally, in the 2021 reporting year, the terms "biodiversity" and "natural environment" appeared only three (3) times in Mr. Price Group Limited's integrated report, whereas they appeared 29 times in Anglo American PLC's report for the same financial year.

**Source(s):** Authors' own work.

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## Notes

1. For example, Sustainable Development Goal (SDG) 15 focuses on the sustainable use of ecosystems and the reduction of biodiversity loss, while SDG 14 emphasizes the conservation and sustainable use of oceans, seas, and marine resources.
2. Based on the NBBN biodiversity scoring scheme.

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**Corresponding author**
Abongeh A. Tunyi can be contacted at: tunyi.abongeh@swansea.ac.uk

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