

Review

# Toward More Nature-Positive Outcomes: A Review of Corporate Disclosure and Decision Making on Biodiversity

Maheshika Senanayake<sup>1</sup>, Iman Harymawan<sup>2</sup> , Gregor Dorfleitner<sup>3</sup> , Seungsoo Lee<sup>1,4</sup>, Jay Hyuk Rhee<sup>2,5,6,\*</sup> and Yong Sik Ok<sup>1,2,5,\*</sup> 

- <sup>1</sup> Korea Biochar Research Center and the Division of Environmental Science and Ecological Engineering, Korea University, Seoul 02841, Republic of Korea
- <sup>2</sup> Center for Environmental, Social, and Governance Studies (CESGS) and the Department of Accountancy, Faculty of Economics and Business, Universitas Airlangga, Surabaya 60132, Jawa Timur, Indonesia
- <sup>3</sup> Department of Finance, Universität Regensburg, 93053 Regensburg, Germany
- <sup>4</sup> Department of Finance, Risk & Compliance, PricewaterhouseCoopers Consulting (PwC), Seoul 04386, Republic of Korea
- <sup>5</sup> International ESG Association (IESGA), Seoul 06621, Republic of Korea
- <sup>6</sup> School of Business Administration, Korea University, Seoul 02841, Republic of Korea
- \* Correspondence: jayrhee@korea.ac.kr (J.H.R.); yongsikok@korea.ac.kr (Y.S.O.)

**Abstract:** Loss of biodiversity and natural degradation are vital issues that have significant impacts on society and economy. Businesses, investors, and regulators have focused on corporate efforts to support biodiversity and nature-positive activities. This review provides a comprehensive overview of the importance of biodiversity for businesses, its materiality, and the roles of mandatory and nonmandatory regulations in corporate environmental reporting and sustainability disclosure frameworks. It also discusses descriptive information on the evolution of sustainability frameworks by comparing the most prominent sustainability frameworks, with a key focus on the materiality approach and biodiversity-related disclosure recommendations. Furthermore, we provide recommendations for more holistic approaches to improve future sustainability frameworks focusing on the impact of biodiversity. Additionally, we demonstrate the necessity for greater focus on the decision-making paradigm. Further research to measure the impact of biodiversity and innovative trends in sustainability reporting is required to better reflect nature-positive outcomes in corporate sector businesses.

**Keywords:** ESG; UN SDGs; sustainability reports; corporate environmental reporting; resilience; sustainable industrialization; biodiversity



**Citation:** Senanayake, M.; Harymawan, I.; Dorfleitner, G.; Lee, S.; Rhee, J.H.; Ok, Y.S. Toward More Nature-Positive Outcomes: A Review of Corporate Disclosure and Decision Making on Biodiversity. *Sustainability* **2024**, *16*, 8110. <https://doi.org/10.3390/su16188110>

Academic Editor: Jooh Lee

Received: 23 July 2024

Revised: 6 September 2024

Accepted: 14 September 2024

Published: 17 September 2024



**Copyright:** © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

Biodiversity loss and destruction of natural ecosystems are critical global challenges owing to their significant consequences for both society and the economy [1]. Biodiversity can be defined as the various living organisms in each area. It includes the differences among individual species and their interactions and relationships. It also incorporates the taxonomic, phylogenetic, and functional aspects that demonstrate the richness of life on Earth [2].

Factors such as climate change, environmental pollution, land use variations, excessive exploitation of resources, and the spread of invasive species are the main causes of biodiversity decline. These issues are generally linked to broader problems such as unsustainable production and consumption [3]. Approximately one million out of the estimated eight million plant and animal species on Earth are at risk of extinction [4]. Human activities such as fishing and pollution affect approximately 66% of the world's ocean area. In addition, nearly 90% of global marine fish stocks are fully exploited, overexploited, or depleted. Nearly 40% of the world's insect pollinators are at risk of extinction owing to factors such

as pollution, habitat destruction, and climate change. The World Economic Forum's Global Risks Report for 2024 identified pollution as a key challenge among the top ten risks endangering the planet [5]. This demonstrates the urgent need for conservation measures to address the hazards encountered by biodiversity and marine ecosystems. The emergence of corporate biodiversity and nature-positive outcomes is a result of the urgent need to protect and enhance biodiversity. These terms describe the actions and initiatives undertaken by businesses to mitigate their impact on the environment and promote sustainability. Nature positivity is a concept aimed at halting and reversing the losses in biodiversity and ecosystems; more concretely, the NPI defines nature positivity as a global societal goal to "halt and reverse nature loss by 2030 on a 2020 baseline, and achieve full recovery by 2050" [6]. The process by which a business provides its stakeholders with information about its biodiversity impact and activities is known as corporate biodiversity reporting [7].

Current worldwide assessments emphasize that the deterioration of the natural world poses a substantial risk to the effective operation of communities and economies. These assessments reveal the importance of key modifications in systematically addressing the loss of biodiversity [8]. Acknowledging the importance of addressing environmental impacts has impelled an increasing number of businesses to incorporate biodiversity- and ecosystem-related information into their sustainability reports. Businesses using resources, as well as producing polluting substances, have direct impacts on biodiversity. One such industry affecting biodiversity is mining. On a wide range of spatial dimensions, from local sites to larger landscapes, regions, and even worldwide, mining activities have a significant impact on biodiversity. Of the total deforestation that occurred in Guyana between 2000 and 2009, 60% was caused by gold mining. Ninety percent of all deforestation in 2009 came from the loss of 9000 hectares of forest as a result of this. Every year, 2300 km of water streams in the United States deteriorate because of coal mining [9].

Businesses are increasingly being compelled to prioritize biodiversity awareness because of its significant impact on the global biodiversity crisis. Biodiversity initiatives address environmental concerns, unlock innovation opportunities, enhance product appeal, and reduce operational expenses. Sustainability reporting standards such as the Global Reporting Initiative (GRI) emphasize the importance of including biodiversity in reporting obligations. It should encompass the count of protected species and the extent of land managed for conservation purposes [10]. This growing trend highlights the significant role businesses play in safeguarding the natural environment while simultaneously ensuring their long-term sustainability and profitability. Certain companies that leverage their strategic positions can enact changes through widespread effects [11]. Investors are evaluating methods to include biodiversity considerations in their evaluations and directing funds toward nature-friendly approaches [12]. This shift is evident as certain business leaders acknowledge their role and seek to rectify inclusion of biodiversity, since companies are particularly inclined to alter their business models. Overall, a positive trend toward biodiversity conservation is apparent in the business domain [13].

Corporate biodiversity and nature-positive outcomes provide numerous advantages. First, these enable companies to manage the risks caused by natural resource scarcity, climate change, and regulatory compliance [14]. By proactively engaging in biodiversity conservation and ecosystem restoration, businesses can enhance their resilience to environmental shocks and uncertainties. It is vital to strengthen the accountability of organizations with regard to biodiversity to ascertain whether businesses are fulfilling their role as caretakers of Earth's biological diversity. This entails evaluating how they handle their influence on ecosystems and species and proactively address the risk of extinction [15]. Incorporating strategies that prioritize biodiversity and positive interactions with nature into business activities can motivate innovation and induce value creation. Companies can devise new products, services, and business models that suit sustainability objectives by considering environmental and social aspects [14,16]. This approach lays the foundation for creativity, promotes resource efficiency, and opens up new market opportunities. Incorporating corporate practices that support biodiversity and have positive impacts on nature

can help achieve global sustainability milestones including the Sustainable Development Goals (SDGs). This is particularly relevant to Goal 6 (addresses clean water and sanitation), Goal 13 (focuses on climate action), Goal 14 (concerns life below water), and Goal 15 (relates to life on land). These support the targets mentioned in the Paris Agreement [17]. Businesses play a critical role in supporting these goals by actively participating in the conservation and restoration of ecosystems and biodiversity [18]. Global entities, such as the Convention on Biological Diversity (CBD) and United Nations Framework Convention on Climate Change (UNFCCC), have emphasized the importance of corporate commitment to biodiversity and nature positive results. Businesses can contribute to the global efforts to conserve and restore nature, mitigate climate change, and ensure a sustainable future by promoting corporate biodiversity. The Task Force on Nature-Related Financial Disclosures (TNFD) was founded to support a shift toward a sustainable and more nature positive economy. The TNFD primarily aims to provide businesses with a framework to disclose their impacts and dependencies on nature and integrate this information into financial decision-making processes [18].

This initiative acknowledges the critical link between a company's financial activities and their implications for nature and biodiversity. This review comprehensively analyses the status related to the knowledge of corporate biodiversity and nature-positive outcomes. It aims to identify the drivers and obstructions to businesses' adoption of nature-positive strategies, evaluate key sustainable frameworks, and assess recommendations for biodiversity and ecosystem protection. This study also focuses on the challenges and opportunities of integrating nature-related disclosures into financial reporting and decision making. It provides insights into how businesses can align their strategies toward nature conservation and restoration goals. The study aims to contribute to the understanding and advancement of corporate practices that prioritize biodiversity and nature-positive outcomes by examining the existing literature and research.

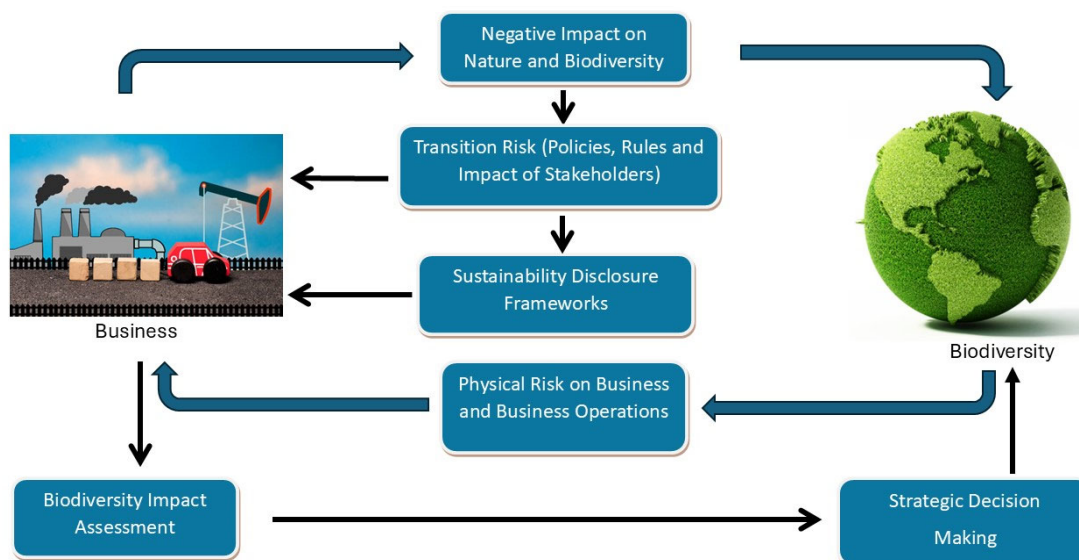
## 2. Biodiversity and Nature-Related Issues

### 2.1. Importance of Biodiversity in the Corporate Environment

Over the past 50 years, human activities have resulted in a considerable loss of biodiversity compared with history. This is impelled by the need to support a growing population's demands for fresh water, food, timber, and fuel [19]. The depletion of resources and pollution has had extensive consequences. This has compelled businesses to reassess their operations that directly or indirectly rely on biodiversity and natural resources [20]. The risks to a company owing to the loss of nature can be straightforward. For example, agricultural firms experience reduced crop yields because of a reduction in pollination or soil health. One such example are nature-based tourism (NBT) companies in Scandinavia, which are deeply dependent on their natural surroundings. These businesses, which offer activities like hiking, biking, skiing, hunting, fishing, and kayaking, are closely tied to unmodified natural and rural areas. The entrepreneurs in this sector often prioritize the sustainable use of the environment over profit and growth because of their direct reliance on nature. This sensitivity toward environmental impact stems from their need to maintain the very landscapes and ecosystems that their businesses depend on, highlighting a complex relationship where the preservation of nature is essential for the sustainability and success of their ventures [21]. There are also long-term hazards that exist, such as the potential hazard to any organization originating from the emergence of zoonotic diseases caused by variations in land use or wildlife trade [22].

Business operations can exert negative impacts on nature and biodiversity. This presents biodiversity-related transition risks for organizations (see Figure 1). These risks originate from a disconnect between economic activities and efforts to safeguard nature, including regulatory changes, legal precedents, technological advancements, and shifts in investor and consumer preferences [23]. Similar to climate change, biodiversity-related transition risks can disrupt production, global value chains, and productivity. This, in turn, can result in reduced corporate profitability. Consequently, these effects can propagate

through the financial system and thereby, affect asset valuations and macroeconomic variables such as exchange rates and commodity prices [24].



**Figure 1.** Biodiversity risks for businesses and assessment of biodiversity impact.

Moreover, nature and biodiversity pose physical risks to businesses (Figure 1), originating from the degradation of natural ecosystems and the subsequent loss of ecosystem services. These risks can manifest as acute or chronic events contingent on variations in both biotic and abiotic conditions necessary for supporting healthy ecosystems. Certain biodiversity-related physical risks may materialize financially within a shorter timeframe than the anticipated impacts of climate change. This would compel businesses to assess and mitigate their biodiversity footprint [23,25]. Hence, it is vital for businesses to evaluate their impacts on biodiversity and make informed strategic decisions to minimize these effects. This will ultimately play a pivotal role in promoting biodiversity conservation efforts (Figure 1).

To address these challenges, sustainability frameworks and standards have emerged that mandate the disclosure of biodiversity-related impacts by business sectors [26]. Such disclosures are instrumental in informing strategic decision making that positively influences nature. Conventionally, environmental impact assessments (EIAs) focus only on pollution. However, advanced approaches integrate biodiversity with health, social, and environmental factors. Biodiversity is now a key consideration in corporate agendas. It is considered as both risk and opportunity. This emphasizes the need for a comprehensive assessment and robust environmental management. Effective biodiversity management reduces risks, promotes opportunities, and enhances stakeholder relationships and operational stability [27]. International initiatives, such as the UN SDGs (2015) and planetary boundaries, in conjunction with the Dasgupta Review (2021), emphasize “The vital role of biodiversity in maintaining the sustainability of both natural and socioeconomic systems [28]”. Almost all nations in the world have agreed to support the CBD and its Global Strategic Plan for Biodiversity 2011–2020. It includes 20 Aichi Biodiversity Targets. This assistance has been extended to the forthcoming global biodiversity framework post-2020. Nevertheless, none of the Aichi Biodiversity Targets have been achieved completely. Approximately one-third of these are either experiencing stagnation or exhibiting indications of a negative shift [29,30].

An analysis conducted in 2020 on the progress of the Aichi Biodiversity Targets set at the 2010 summit revealed that 15 of the 20 listed targets were partially satisfied. However, one target indicated zero progress, and the remaining five displayed negative progress indicating a trend toward adverse effects [30]. Acknowledging the urgency

of this situation, research and practical efforts to understand and measure the impact of business operations on biodiversity is increasing. Collaborative initiatives involving various groups, platforms, and partnerships are working actively to assist businesses and financial institutions in comprehending and mitigating biodiversity impacts [29]. The goal of these collective actions is to equip businesses with the necessary tools and standards to consider the effects and advantages of biodiversity in their decision-making processes [20]. Two examples of these tools are the Integrated Biodiversity Assessment Tool (IBAT) and the Global Biodiversity Score (GBS), which are essential for biodiversity assessment. IBAT, developed with the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN), offers critical data on protected areas and key biodiversity areas, supporting informed decision making for conservation [31]. The GBS, created by CDC Biodiversité, helps companies measure and manage their biodiversity footprint, enabling them to align their strategies with global conservation goals and enhance their environmental performances [32]. These tools can be used by businesses to assess environmental risks and ensure compliance with biodiversity regulations, as well as to measure and manage their biodiversity footprint and enhance transparency with stakeholders.

Owing to the failure of the Aichi Biodiversity Targets, COP15 introduced the Kunming–Montreal Global Biodiversity Framework in December 2022. It aims to halt and reverse biodiversity loss by 2030. It builds upon the Strategic Plan for Biodiversity 2011–2020 [33]. It seeks to restructure humanity’s relationship with biodiversity and is aligned with the 2030 Agenda for Sustainable Development. The ultimate goal is to achieve a harmonious coexistence with nature by 2050 [34]. Notwithstanding the introduction of the 2010 Biodiversity Strategy by the European Union, the companies listed in the EU exhibit limited commitment to biodiversity protection [35]. This emphasizes the importance of aligning policy initiatives with corporate actions to address the deficiency and ensure an effective commitment by the corporate sector to reveal its impact on biodiversity and nature.

Biodiversity mainstreaming, as defined by the Convention on Biological Diversity and the UNEP, emphasizes the integration of biodiversity considerations into decision making across various sectors [36]. However, notwithstanding substantial investments and efforts to enhance these tools, persistent deficiencies remain in the existing criteria for biodiversity in certification, standards, business accounting, and scientific modeling [29]. In addressing these challenges, a pragmatic strategy known as “embedded mainstreaming” was suggested by Smith et al. (2020). It recommends bundling biodiversity considerations within broader frameworks such as environmental, natural capital, and mainstream climate change [37]. The aim is to ensure the effective integration of biodiversity concerns amid competing priorities, particularly in a world with limited resources.

## *2.2. Role of Mandatory and Nonmandatory Regulations on Corporate Environmental Reporting*

Economic evidence indicates that the damage to nature caused by businesses can affect a company’s financial health [38]. Failure to satisfy biodiversity standards can result in fines, license revocation, customer dissatisfaction, employee disengagement, and increased capital costs. Conversely, achieving a strong biodiversity performance can facilitate capital access, maintain operational permission, and cultivate loyalty among customers and staff [39]. According to a KPMG report in 2022, from the list of top revenue-earning companies they studied, less than 50% reported their biodiversity-related risks and impacts. Among them, the highest percentage of companies reporting on biodiversity loss was in the mining sector, with 79%. Following closely were companies in the forestry and paper sectors, at 76%. In contrast, the healthcare sector reported the lowest percentage, with only 17% of companies acknowledging the risk of biodiversity loss [40]. A study by Hassan et al. (2020) investigated the biodiversity and extinction (B/E) disclosure practices of the top 200 Fortune Global companies, using greenwashing and impression management theories to understand the motivations behind these disclosures [41]. A 53-item disclosure index was developed to assess the extent of B/E reporting, and a model was

tested to explore the relationships between B/E disclosures and various determinants, such as company performance, industry sector, country, assurance, environmental awards, and species-related disclosure. According to the biodiversity and extinction reporting by the top 200 Fortune Global companies is minimal, with very few companies providing substantial information. Even the companies with higher disclosure scores showed inconsistency across different reporting themes.

The introduction of the Greenhouse Gas Reporting Program (GHGRP) in the United States reduced the environmental litigation risks for corporations [42]. The study also revealed the importance of the mandatory reporting of greenhouse gas (GHG) emissions for determining companies' environmental conduct. It emphasized the interconnectedness between regulatory actions, corporate responsibility, and financial results.

Charitou (2022) analyzed the impact of the European Union (EU) legislation on corporate environmental disclosures in Europe [43]. The study observed that regulations have resulted in an increase in the extent of environmental disclosure. Tang and Demeritt (2017) compared the GHG emissions before and after Mandatory Carbon Reporting (MCR) [44]. The observations revealed that all the sectors experienced an increased percentage of sustainability reporting post-MCR implementation. However, imposing mandatory reporting requirements may not uniformly increase the standard of nonfinancial disclosures, particularly for companies already engaged in voluntary sustainability reporting. Carungu et al. (2020) indicated that mandating companies to disclose nonfinancial reports (NFRs) does not consistently result in an overall improved quality of the reports [45]. Approximately 25% of the companies that voluntarily shared additional sustainability reports did not show enhanced quality in their disclosures even when NFRs were mandatory [44]. Similar consequences can be anticipated when nature positivity is reported.

### 3. Corporate Sustainability Disclosure Frameworks

#### 3.1. Corporate Sustainability Disclosures: Evolution Throughout History

In transitioning to corporate sustainability, the evolution of sustainability reporting frameworks has achieved significant milestones. As investors display a growing interest in nonfinancial information, various sustainability accounting frameworks have been introduced to standardize the reporting of environmental, social, and governance (ESG) data [46]. Developing sustainability frameworks involves the consideration of two key perspectives: the sustainability paradigm (environmental, social, and economic) and decisional paradigm (strategic, tactical, and operational). Integrating both is important for effective implementation. However, studies have observed limited integration in decision-making aspects [47].

In et al. (2023) examined the evolution of sustainability reporting guided by Kuhn's scientific revolution theory [48]. They revealed four key periods in sustainability reporting. The initial phase (1973–2005) did not have a consensus on theories. The subsequent period (2006–2011) experienced an increase in the number of conceptual frameworks that dominated the landscape. The following years (2012–2015) underwent a crisis phase with increased empirical analysis and shifts in attention to integrated reporting and sustainability transition. The most recent period (2016–2019) indicated a potential paradigm shift, with sustained interest in sustainability reporting. This period is designated as the age of stakeholder engagement. The focus has shifted considerably toward acknowledging the significance of materiality in sustainability considerations [48]. Sustainability reporting is displaying a growing trend. Although the initial emphasis was on reporting climate-related issues, a shift in the trend toward addressing broader nature-related issues has been observed [49]. Primary contemporary sustainability reporting frameworks and standards have been established by influential entities such as the GRI, Sustainability Accounting Standards Board (SASB), Climate Disclosure Project (CDP), and Climate Disclosure Standards Board (CDSB). These frameworks are pivotal in guiding organizations in the disclosure of their ESG performances [46].

Since its establishment in 1997, the GRI has been the leading framework for sustainability reporting (Figure 2). It was founded in partnership with organizations such as the Coalition for Environmentally Responsible Economies (CERES) and UN Environment Program (UNEP). It introduced the G4 guidelines in 2013, thereby reinforcing its commitment to providing comprehensive standards for organizations engaged in sustainability reporting [50]. The GRI addresses the information requirements and expectations of various stakeholders across sectors [51]. The CDP was established in 2000 (Figure 2) [52]. It is an online reporting infrastructure. Its main purpose is to provide stakeholders with the autonomy to disseminate information unilaterally [53]. The GHG Protocol was initiated in 2004 (Figure 2). It is a universal, standardized framework on a global scale. These frameworks facilitate the quantification and regulation of GHG emissions across both private and public sector activities, supply chains, and efforts to reduce emissions [54]. The CDSB provides companies with a structured approach to reporting environmental data. This framework was introduced in 2010 (Figure 2). It enables companies to provide investors with relevant environmental insights in their regular corporate reports. The SASB framework was introduced in 2011 (Figure 2). The objective was to create and promote standards for sustainability accounting that enable publicly traded companies to communicate relevant and valuable information to investors [55].

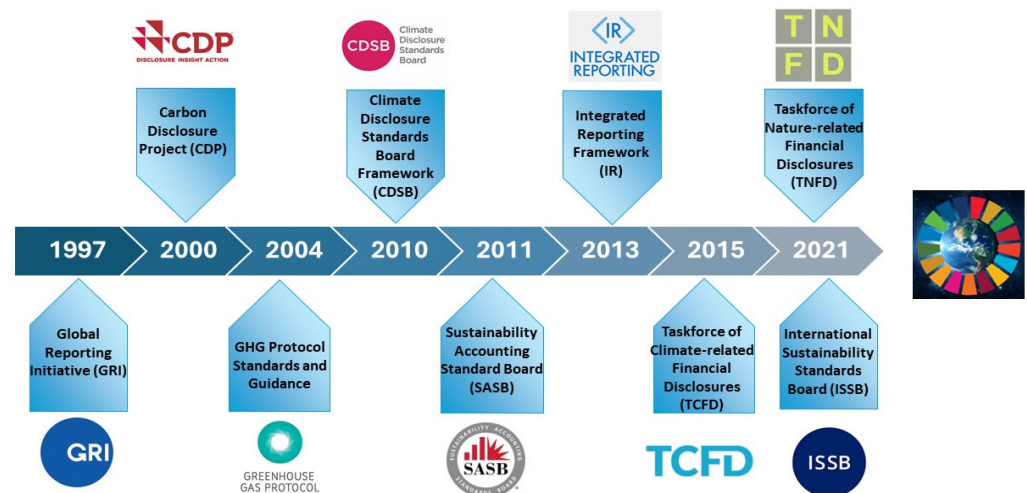


Figure 2. Evolution of sustainability frameworks (adapted from [56]).

Since its inception in 2013 (Figure 2), the International Integrated Reporting Framework has aimed to expedite the global uptake of integrated reporting. Improving the quality of the information available to financial stakeholders facilitates a more efficient allocation of capital. Moreover, it supports a unified and thorough approach to corporate reporting. Thereby, it integrates various reporting aspects to convey the full spectrum of factors influencing an organization's long-term value creation [57].

The Taskforce of Climate-Related Disclosures (TCFD) initiative was introduced in 2015 (Figure 2). It is actively formulating guidelines for disclosing climate change-related risks [58]. The TCFD provides a broad definition of climate risk. This definition focuses on two main categories of risks: the challenges associated with transitioning to a lower-carbon economy and the potential impacts of climate change on the physical environment [59]. However, both G20 and G7 (which comprise the heads of state and governments of leading industrial nations) have identified a deficiency in best practices that specifically address the management of natural risks [60]. Analysis done by Nascimento et al. (2021) on G20 climate policies reveals that there are major gaps, including inconsistent support for renewables and inadequate policies for fossil fuel phase-out, with some emissions still uncovered by existing policies [61]. Fyson et al. (2022) explain the gaps of G7 to meet the Paris Agreement's 1.5 °C goal [62]. Their current emissions targets are insufficient, and none of the G7 countries are on track to meet even these goals. Additionally, Fyson et al.

(2022) explain that the G7 does not provide adequate support for developing countries to help with global decarbonization efforts. Because of these gaps many of the sustainability frameworks may not fully capture the effectiveness or shortcomings of actual policies. As a result, sustainability reports may present an overly optimistic view, failing to address critical areas where policy actions are lacking or misaligned with global climate goals. The TCFD and CDP play significant roles in supervising environmental risks and demonstrating leadership in this domain [63]. The TNFD has similar goals and may become a leading authority in disclosing risks related to nature [64]. As concerns regarding the perceived risks associated with climate change grow, companies in various industries are adjusting their corporate risk-management approaches to align with the recommendations of the TCFD. Particularly, the automotive, oil and gas, mining, and financial services sectors are leading the way in incorporating these recommendations into their risk-management strategies. These are outpacing other industries in this regard [53].

The goal of the TNFD was to set up a unified system for financial institutions to report on biodiversity-related Financial Risks (BRFRs) starting in 2021. This approach followed a structure similar to that of the established TCFD [18]. The TNFD significantly influences corporate and financial practices by emphasizing the integration of sustainable approaches and robust risk management [23,64]. Its comprehensive recommendations show a versatile framework appropriate for entities of all sizes. The focus is on identifying and disclosing nature-related issues. TNFD provides strategic disclosures for the Kunming–Montreal Global Biodiversity Framework. This collaboration is a significant step toward achieving global biodiversity goals and can positively influence sustainability and environmental resilience [23].

It is important for companies engaging in sustainability reporting to understand the main sustainability frameworks, such as the GRI, SASB, CDP, TCFD, and TNFD. According to the Cambridge dictionary, materiality is “a measure of how important a piece of information is when making a decision”. The GRI standards define a topic as material if it reflects the company’s most substantial impacts on the economy, environment, and people, including those related to human rights [65] (Table 1).

This table shows the purpose, stakeholder focus, materiality approach, disclosure structure, and biodiversity approaches. It provides a clear and concise overview of each framework’s features and applicability. Thereby, it would support companies in selecting compatible frameworks for their reporting requirements. Furthermore, it reveals the contribution of selected frameworks for biodiversity disclosures. It also highlights the improvements necessary to create robust frameworks for biodiversity disclosures.



**Table 1.** Comparison of the following sustainability frameworks: GRI, SASB, CDP, TCFD, and TNFD.

Characteristic	GRI	SASB	CDP	TCFD	TNFD
Purpose	To support in the decision-making relationship to economic, environmental, and social impacts of an organization [53,66].	To create and promote standards for sustainability accounting that enable publicly traded companies to communicate relevant and valuable information to investors [67].	An extensive online reporting system that empowers stakeholders to independently share information, thereby facilitating the effective management of environmental impacts [53].	An initiative to provide reports that address both dependencies and impacts on the environment. Facilitate adherence to established and widely acknowledged reporting standards for organization [68].	To create a standardized framework for financial institutions to disclose biodiversity-related financial risks (BRFR) starting in 2023 [23].
Stakeholder focus	Investors, consumers, employees, and civil society [46].	Investors, companies, and corporate issuers [53,69].	Company, investors, and customers [53].	Companies, investors, lenders, insurance underwriters, and other stakeholders [70].	Companies, investors, lenders, insurance underwriters, and other users [23].
Materiality approach	Double materiality approaches, both financial materiality and societal materiality [71]. Assessing whether the process of an organization contributes positively or negatively to sustainable development [66]. Disclosing material information of the organization that affects positively and negatively on environment, economy, and society [53].	Financially material sustainable information is essential for short-, medium-, and long-term value creation [53]. A material topic has an impact on the financial condition or operating performance of an organization [71]. SASB provides a materiality map that delineates potentially significant issues at both sector and industry levels. At the sector level, the map indicates whether specific issues are likely to be material for over 50%, less than 50%, or none of the industries within that sector [53].	Follows the Climate Disclosure Standard Board's materiality approach [53].	Recommends that organizations assess the materiality of climate-related information in a manner similar to how they evaluate the significance of other details included in their financial disclosure [68].	Satisfying the information requirements of capital providers aligning with ISSB's IFRS Standards and TCFD recommendations while also addressing stakeholders' concerns related to impacts, in coherence with a comprehensive materiality approach as outlined in the GRI Standards [23].
Disclosure structure	Four main categories: management approach, economic performance, environmental performance, and social performance [53]. Standards for sustainability reporting: 1. GRI 101: Foundation 2016. 2. GRI 102: General. 3. Disclosures 2016. 4. GRI 103: Management. 5. GRI 200: Economic Standards. 6. GRI 300: Environmental. 7. Standards. 8. GRI 400: Social Standards [68].	Categorized into five areas: environment; social capital; human capital; business model; and innovation, leadership, and governance [53]. The SASB Standards includes 77 industries distributed across 11 sectors [68].	Three major disclosure areas: climate change, forests, and water security. State and region-specific disclosure themes: governance, region-wide emission, strategy, risks and adaptation, water security, and forest. City-specific disclosure themes: governance, climate hazards, adaptation, city-wide emissions, emission reduction, opportunities, local government emissions, energy, building transport, urban planning, food waste, and water security [53].	The disclosure structure has four key segments: governance, strategy, risk and impact management, and metrics and target [23].	The disclosure structure has four key segments: governance, strategy, risk and impact management, and metrics and target [23].

Table 1. Cont.

Characteristic	GRI	SASB	CDP	TCFD	TNFD
Feasibility of utilizing the framework in collaboration with other frameworks?	Feasible GRI is designed to function as a guide for developing a customized sustainability report for a company. The report induces and simplifies the incorporation of metrics and reporting specifics from other frameworks [68].	Feasible SASB aims to identify financially significant sustainability information. Therefore, the resulting data, metrics, and narrative are designed explicitly for seamless integration into both regulatory filings and publicly released sustainability reports [68].	Feasible CDP is aligned with ISSB, GRI, TCFD, and TNFD recommendations [72].	Feasible Compatible with established reporting frameworks such as CDP, SASB, CDSB, GRI, and IIRC. The entities that are already employing these frameworks may identify effective resources within the TCFD framework to aid in the collection and disclosure of climate-related information [68].	Feasible The TNFD recommendations were developed to align with existing reporting frameworks such as CDP, SASB, CDSB, GRI, and IIRC [23].
Biodiversity approach	GRI 304: Biodiversity 1. Management approach disclosures. 2. Topic specific disclosures. Disclosure 304-1: Operational sites owned, leased, and managed in (or adjacent to) protected areas and areas of high biodiversity value outside protected areas. Disclosure 304-2: Significant impacts of activities, products, and services on biodiversity. Disclosure 304-3: Habitats protected or restored. Disclosure 304-4 IUCN: Red-list species and national conservation list species with habitats in areas affected by operations [73].	Environmental disclosures include 1. GHG emissions: direct (Scope 1). 2. Air quality: airborne pollutants. 3. Energy management: management of energy efficiency and intensity, energy mix, as well as grid reliance. 4. Water and wastewater management. 5. Waste and hazardous materials management. 6. Ecological impacts: manage company impacts on ecosystems and biodiversity.  Includes exploration, resource extraction, cultivation, project development, construction, biodiversity loss, habitat destruction, and deforestation across all the project stages. Does not address impacts of climate change on ecosystems and biodiversity [55].	Four main questionnaires are based on climate change, forest stewardship, water security, and plastic pollution. CDP's climate change questionnaire, in alignment with TCFD recommendations, would integrate ISSB's climate disclosure standard from 2024. CDP's forests questionnaire aligns with the Accountability Framework. CDP's questions on plastics are based on established frameworks such as The Ellen MacArthur Foundation and UNEP's Global Commitment [74].	GHG Emissions Absolute Scope 1, Scope 2, and Scope 3; emissions intensity. Amount and extent of assets or business activities vulnerable to transition risks. Capital expenditure, financing, or investment deployed to address climate-related risks and opportunities [70].	Discuss extensively regarding the biodiversity disclosures. 1. Total spatial footprint. 2. Total surface area controlled/managed by the organization. 3. Extent of land/freshwater/ocean-use variation. 4. Mean species abundance (MSA). 5. Potentially disappeared fraction of species. 6. Proportion of land degraded. 7. Keystone species: variations in populations of priority identified species (keystone species). 8. Forest Structural Condition Index: combines data on forest extent with data on forest structure. 9. Species Threat and Restoration Metric (STAR). 10. Global Extinction Probability (GEP). 11. Persistence Score (PS). 12. Occurrences: Measures the number of individuals of a species of interest in a specific area [23].

### 3.2. Comparison of Sustainability Frameworks

A comparison of the main sustainability reporting frameworks reveals differences in their priorities, such as scopes, stakeholder focus, and materiality [75]. The GRI standards provide flexibility for thorough reporting, SASB specializes in industry-specific metrics, CDP facilitates an online platform for companies to disclose their preparedness regarding climate change risks and opportunities, and TCFD provides guidance on disclosing financial risks related to climate change and supports adherence to reporting standards addressing environmental dependencies and impacts [53]. The TNFD focuses mainly on biodiversity. It creates a standardized framework for financial institutions to reveal biodiversity-related financial risks. This approach emphasizes the TNFD's dedication to address the critical issue of biodiversity conservation and integrating it into financial considerations for a more holistic approach to sustainability reporting [23]. Robert Eccles is a prominent figure in the ESG field. He has expressed concerns regarding the complex landscape created by the distinct reporting standards of entities such as SASB, GRI, and TCFD. This has resulted in what he refers to as the "alphabet soup", which has caused ambiguity among companies and investors [76].

Analyzing how sustainability standards define materiality is necessary because these directly impact the issues that companies opt to report. The GRI serves as a comprehensive reporting standard that emphasizes the impact and involves input from multiple stakeholders. The GRI's attention is directed toward an organization's current economic, environmental, and social performance. Its materiality considerations extend beyond only financial matters to include a broader significance [53]. The GRI uses a double materiality approach (Table 1) comprising both financial and societal materiality.

This framework revolves around two key dimensions. First, it evaluates the significance of an organization's economic, environmental, and social impacts. Second, it measures the substantial influence of these impacts on stakeholder assessments and decisions [71]. SASB's conceptualization of materiality may not necessarily reveal critical sustainability issues. Thus, its framework may not be aligned with sustainable development as understood more broadly [71]. TCFD establish voluntary and consistent climate-related financial disclosures designed to assist investors, lenders, and insurance underwriters in evaluating material risk (see Table 1). According to the TCFD, disclosure of financially significant information is a legal requirement in numerous jurisdictions. Therefore, if climate-related information holds financial materiality, it should be a part of the mandatory disclosure. In this context, the TCFD emphasizes that its recommendations are intended to assist organizations in fulfilling their current disclosure obligations more efficiently [59].

A comparison of the materiality approaches of the sustainability frameworks GRI, CDP, SASB, TCFD, and TNFD revealed that these vary in their emphasis on different aspects. GRI Standards uniquely focus on an organization's impact on sustainable development rather than only on its sustainability. The SASB focuses more on financial materiality, which can have a significant impact on the performance of an organization. The CDP aligns with the materiality approach of the Climate Disclosure Standard Board. It emphasizes the significance of climate-related information (Table 1). The TCFD recommends evaluating the materiality of climate-related information, similar to other financial details. TNFD addresses the informational requirements of capital providers in alignment with the standards of the International Sustainability Standards Board (ISSB) and recommendations of TCFD while concurrently satisfying stakeholders' requirements with a comprehensive materiality approach following GRI Standards.

The sustainability frameworks examined, including the GRI, SASB, CDP, TCFD, and TNFD, present diverse approaches to environmental- and biodiversity-related disclosures. The GRI emphasizes both management- and topic-specific disclosures with a focus on biodiversity protection and habitat restoration. GRI 304: Biodiversity standards comprise the following two main aspects: the management approach and topic-specific disclosure (see Table 1). The four key disclosures include details on operational sites in or near protected areas (304-1), significant impacts on biodiversity (304-2), efforts toward habitat

protection or restoration (304-3), and the identification of species in affected areas (304-4). These disclosures aim to enhance the transparency in an organization's biodiversity management.

The ISSB issued its sustainability reporting standards as the International Financial Reporting Standards (IFRS) in June 2023. The IFRS sustainability disclosure standards are derived from the following four foundational elements of the TCFD framework: governance, strategy, risk management, and metrics with associated targets. These standards focus mainly on financial materiality [77].

The IFRS framework incorporates several standards that address environmental concerns directly and indirectly. IFRS 6 focuses on extractive industries, IFRIC 5 guides decommissioning and restoration expenses, and the ongoing discussions on IFRIC 3 and IAS 38 address government-allocated emissions rights [78]. The IFRS comprehensively addresses various environmental aspects. Nonetheless, it is important to note that the current recommendations do not explicitly provide detailed guidance on disclosures related to biodiversity.

SASB addresses a broad spectrum of issues related to environmental protection, including GHG emissions, air quality, energy management, waste and wastewater management, hazardous waste management, and ecological impact (Table 1). These standards address biodiversity loss, habitat destruction, and deforestation at all stages. However, these do not include the broader impacts of climate change on ecosystems and biodiversity. The CDP questionnaires align with the TCFD and established frameworks. It anticipates future mandatory reporting standards (Table 1). It currently utilizes the following four main questionnaires for environmental disclosure: Climate Change, Forest Stewardship, Water Security, and Plastic Pollution. Aligned with TCFD recommendations, the Climate Change questionnaire integrates ISSB's climate disclosure standard. It enables disclosing companies to anticipate future mandatory reporting aligned with TCFD standards. The Forests Questionnaire aligns with the Accountability Framework. This enables companies to satisfy the expectations of buyers, investors, and stakeholders. The CDP's questions on plastics are based on established frameworks such as The Ellen MacArthur Foundation and UNEP's Global Commitment. It transforms complex guidelines into a standardized annual format by incorporating best practices [74]. Nevertheless, these questionnaires do not appear to directly address disclosures related to their impact on biodiversity. The primary focus of the TCFD is climate-related disclosures encompassing GHG emissions (Absolute Scope 1, Scope 2, and Scope 3) and emission intensity. Additionally, it describes the assessment of assets or business activities vulnerable to transition risks, and quantifies the capital expenditure, financing, or investment dedicated to climate-related risks and opportunities.

The TNFD pays close attention to biodiversity disclosures and evaluates different aspects to understand how organizations affect ecosystems. The disclosures recommended by the TNFD Framework address many aspects such as the total area an organization manages and any areas that have been disturbed or restored. Further variations in land, freshwater, and ocean use are considered based on the type of ecosystem and business activities involved. The TNFD also focuses on the average abundance of species, potential loss of species owing to human activities, and the extent of land degradation. These assess the variations in the populations of important species; the condition of forests; and metrics such as the Species Threat and Restoration Metric (STAR), Global Extinction Probability (GEP), Persistence Score (PS), and occurrence (Table 1). This comprehensive approach helps evaluate an organization's impact on biodiversity according to the TNFD guidelines for 2023. Furthermore, the TNFD has provided additional sector guidelines for specific sectors that recommend further disclosures related to nature-related issues owing to their significant influence on nature [23]. These sector guidelines focus mainly on key industrial sectors such as oil and gas, metal and mining, forestry and paper, food and agriculture, electric utilities and power generation, chemicals, biotechnology and pharmaceuticals, aquaculture, and financial institutions. There is significant potential for the development of sector-specific guidance in industries such as automobile, consumer durables, apparel,

and retail construction to mitigate their considerable impact on the environment. Further, Deweerdt et al. (2022) state that the TNFD's targets and metrics exhibit the following six key features: clear differentiation between preparation and disclosure metrics, consistency with TCFD standards, applicability throughout the value chain, universality across sectors, periodic evaluations for ongoing relevance, and alignment with anticipated international frameworks, such as the Convention on Biological Diversity and the Science-based Targets Network [64]. This design ensures robust and adaptable metrics for effectively addressing nature-related risks, particularly considering the negotiations at COP15. Furthermore, the TNFD and ISSB have decided to collaborate on nature-related issues. This would significantly accelerate business-driven biodiversity conservation efforts [23].

The overall comparison of the selected sustainability frameworks emphasizes the TNFD's higher focus on biodiversity-related corporate disclosures. This distinguishes it from the TCFD, which focuses primarily on climate change (Table 1). Although the GRI, SASB, and CDP address environmental and biodiversity protection in their disclosure recommendations and standards, these do not prioritize extensive disclosures related to biodiversity impacts compared with the TNFD. The TNFD acknowledges the absence of standardized metrics for communicating nature-related risks to investors and the public. It is challenging to interpret and compare the currently available information across industries. To address this deficiency, the TNFD has developed consistent standard metrics. These metrics align with existing and upcoming initiatives including the SASB and ISSB [63].

## 4. Discussion

### 4.1. Limitations of Sustainability Frameworks with Respect to Biodiversity

Biodiversity is inherently complex and multidimensional. It presents a significant challenge for businesses aiming to design successful conservation models [79,80]. The increased public awareness of climate change and biodiversity loss has placed companies under increased scrutiny. This necessitates the measurement and disclosure of their biodiversity relationships to maintain social approval [81]. But, organizations generally encounter limitations in reporting biodiversity because of inadequate knowledge and disclosure [82]. Critics contend that current reporting standards fail to address the degeneration of nature. This highlights a significant deficiency in accounting for biodiversity losses [83]. Notwithstanding the efforts to integrate sustainability into decision making through evaluation frameworks, practical applications encounter drawbacks and limitations [84]. The existing frameworks lack comprehensive methods to quantify the environmental impact of industry on ecosystems, which are dynamic and subject to natural disturbances [85]. Despite efforts to integrate sustainability into decision making through evaluation frameworks, practical applications encounter drawbacks and limitations [84]. In response Layman et al. (2023) recommended innovative strategies for assessing a company's biodiversity relationships. These include evaluating risks from nature-related factors and minimizing contributions to species extinction risks using datasets [86]. However, the practical applications and real-world impacts of these strategies remain ambiguous. This has stimulated a critical examination of their feasibility. This apparent deficiency in addressing environmental impacts emphasizes the need for a more holistic approach to sustainability frameworks. A comprehensive disclosure mechanism should be established to account for a broader spectrum of biodiversity impacts.

Therefore, we focused on the critical role of biodiversity within corporate environments by examining and contrasting existing sustainability reporting frameworks. With a specific emphasis on biodiversity, we compared these frameworks to gain insights into their approaches to disclosing biodiversity impacts. After the comparison, it clearly shows that the existing frameworks have varied levels of significance given to biodiversity in their indicators and standards. With the development of concerns related to biodiversity among many stakeholders in the industries, the popular and widely used sustainability frameworks should give more focus to aligning their standards to support biodiversity disclosure, motivating companies to adopt more nature-positive strategies. Subsequently, we provide

further recommendations to improve the measurement of the impact of biodiversity on corporate sustainability reporting.

#### 4.2. Suggestions to Improve Biodiversity Disclosure

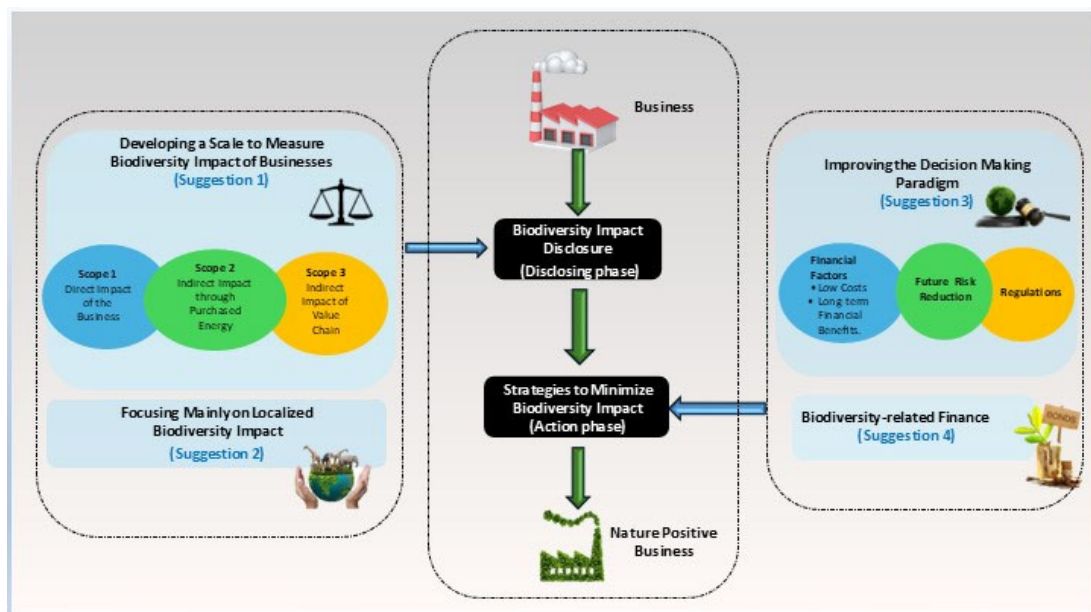
We would like to suggest innovative strategies for assessing a company's biodiversity relationship, including evaluating risks from nature-related factors and minimizing contributions to species extinction threats using datasets. However, the practical application and real-world impact of these strategies remains unclear, prompting a critical examination of their feasibility. This apparent gap in addressing the environmental impact highlights the critical need for a more holistic approach to sustainability frameworks. A comprehensive disclosure mechanism should be established to effectively account for the broader spectrum of biodiversity impacts.

When environmental performance indicators do not effectively evaluate the positive and negative impacts of all the supply chain activities on biodiversity and ecosystem services, companies encounter challenges in providing holistic and standardized corporate responsibility reports [87]. Therefore, there is an urgent need for a comprehensive and standardized set of indicators to evaluate the biodiversity and ecosystem services across the entire supply chain of a focal organization [88]. Additionally, there is a need for government support and policy standards to back these disclosures by enacting proper policies and guidelines. A regulatory approach, supported by scientific engagement in the development of disclosure standards and relevant policy indicators, need to be advocated to ensure positive impacts on biodiversity [89]. As discussed in Section 2.2, regarding the role of mandatory and nonmandatory regulations for corporate disclosure, we suggest that governments support these disclosure initiatives both locally and globally. States should encourage businesses to disclose their nature-related issues and dependencies by enacting appropriate acts and policies. In addition to these existing recommendations, we wish to add the following specific recommendations for improving sustainability disclosure frameworks and corporate decision making regarding biodiversity impacts, to the general discussion.

##### 4.2.1. Recommendation 1: Applying GHG Emissions Methodology to Assess Biodiversity's Impact on Business Operations

Inadequate communication of the adverse effects on biodiversity and ecosystem services, coupled with the divergence between formal reporting practices and practical supply chain management requirements, can result in the absence of transparency in corporate responsibility reporting [90]. The TNFD Framework places a significant emphasis on addressing biodiversity issues originating from both upstream and downstream activities within the business sector [23]. Although these aspects are critical components of the biodiversity impact within the supply chain, it is important to acknowledge that these do not include the entire biodiversity impact. Winter et al. (2017) emphasized the use of a life cycle assessment (LCA) to understand the impact of products on biodiversity [91]. They observed deficiencies such as the omission of genetic diversity and incomplete consideration of biodiversity pressures, and they called for more innovative methods to enhance the LCA's capability to accurately assess biodiversity impacts.

Therefore, we propose adopting a procedure similar to that used for GHG emissions to emphasize the impact of biodiversity on all the aspects of business procedures (Figure 3). This holistic approach should involve developing a disclosure framework that can effectively assess the biodiversity impact originating from the supply chain and from all other direct and indirect aspects of business operations.



**Figure 3.** Strategies to drive corporate sector businesses toward nature-positive outcomes.

**Scope 1—Biodiversity Impact:** quantifying the direct impact of a business entity on biodiversity. Similar to the Scope 1 GHG emissions, this can include activities such as land-use variations, habitat destruction, resource extraction or species endangerment that are directly attributable to the company’s operations.

**Scope 2—Biodiversity Impact:** quantifying indirect impacts similar to the Scope 2 GHG emissions involves assessing the biodiversity consequences of energy and resource procurement, transportation, and other outsourced activities associated with the business.

**Scope 3—Biodiversity Impact:** Quantifying the indirect effects attributable to the products or services provided by a company over its life cycle. This includes assessing the biodiversity footprint associated with raw material extraction, manufacturing, distribution, product use, and disposal, similar to the Scope 3 GHG emissions (Figure 3).

Implementing such a structured disclosure framework enables businesses to systematically assess and disclose their biodiversity impact across scopes. This, in turn, facilitates a comprehensive understanding of their ecological footprints. The approach supports targeted interventions to mitigate adverse effects, promotes conservation efforts, aligns with broader sustainability goals, and promotes harmonious coexistence with the natural environment. Typically, biodiversity impacts tend to be negative. The positive impacts are generally observed as a reduction in these negative effects. However, in a few instances, there may be direct positive impacts such as a product or production process that actively contributes to the enhancement of biodiversity.

#### 4.2.2. Suggestion 2: Focusing on the Localized Biodiversity Impact to Improve Local Biodiversity Preservation

Hardin’s concept of the “tragedy of the commons” (1968) illustrates how individual self-interest can lead to the depletion of shared resources. Recently, evolutionary biologists used this method to analyze various biological systems. They highlighted how similar issues of resource exploitation and depletion can manifest in natural environments [92]. Biodiversity impacts may have both global and local dimensions. This enables companies to observe and respond to their effects at a regional scale, such as land degradation (which directly affects the fauna and flora in that specific area). Although GHG emissions were earlier considered as primarily local, these are now understood to have significant global consequences [93]. The impact on biodiversity typically occurs more prominently at the local level [94]. This localized characteristic of biodiversity impacts would facilitate

companies in profiting from their investments in sustainability measures because the positive impacts on their operations and reputation can be identified more directly.

A few companies have assessed the localized biodiversity impact in their ESG reports. An example is Samsung Heavy Industry. In their 2023 ESG report, they mentioned how they regularly monitored and identified their impact on nearby freshwater and terrestrial ecosystems, ecotoxicity, and domestic wildlife habitats [95]. Mason et al. (2024) have developed a novel methodology to quantify the terrestrial biodiversity supported by green infrastructure, demonstrated in a case study of sedum roofs in London's Meridian Water Development [96]. According to the new approach the sedum roofs supported 53 species, mitigating 1.3% of the in situ environmental impacts. Another example is about Danone, a global leader in the food industry, who has embedded biodiversity into its business strategy through the "One Planet. One Health" initiative. They have implemented regenerative practices like cover cropping, crop rotation, and minimizing chemical usage to enhance soil health, boost biodiversity, and strengthen ecosystem resilience [97]. One another example for successful addressing of localized biodiversity impacts was reported by the S11D Eliezer Batista iron mining complex, operated by Vale. They have achieved significant biodiversity restoration through its reforestation efforts, regenerating 73% of old-growth forest conditions within 4–6 years. These initiatives led to a positive biodiversity balance within the company-managed areas, despite overall environmental degradation in the region [98].

Understanding and quantifying the risks and dependencies that extend beyond national boundaries is a complex task that can pose significant challenges even in the natural sciences [99]. Therefore, the localized characteristic of biodiversity impacts provides companies a clear pathway for integrating environmental considerations into their business strategies (Figure 3). A concrete approach to preserving local biodiversity should be introduced to motivate businesses toward nature positivity.

#### 4.2.3. Suggestion 3: Key Focus on the Decision-Making Aspect of Biodiversity Disclosures

Existing sustainability frameworks primarily focus on revealing the biodiversity impact of various industries. However, the essential step of actively mitigating these impacts through strategic decision making is still in its early stages. This proactive approach is the key to effectively reducing the loss of biodiversity. Therefore, future sustainability frameworks should prioritize motivating industries to focus on decision-making processes aimed at minimizing their impact on the biodiversity. This would promote a more sustainable relationship between industries and the environment (Figure 3). A study by Mintah and Elmarzouky (2024) on Airbnb.org shows that strategically using its digital-platform-based ecosystem strengthens its crisis response, in line with dynamic capabilities theory [100]. This research provides evidence of how digital platforms can effectively deploy CSR during crises. The same approach could be applied to the biodiversity crisis, where digital platforms could leverage their capabilities to support conservation and promote sustainable practices.

Integrating sustainability and decision-making paradigms within sustainability frameworks is essential for successful project execution [47]. This comprehensive perspective aims to combine sustainability and decision-making paradigms and direct efforts toward sustainable outcomes. However, the practical implementation and level of commitment from decision makers are areas that need to be focused on to ensure the effectiveness of such integration. The connection between financial performance and environmental disclosure leans more toward a positive relationship rather than a negative one [101]. Businesses are motivated to incorporate biodiversity into their financial decision making for several reasons. When legal obligations mandate compliance, they become priorities (Figure 3). In addition, if actions can be executed at minimal or zero cost, businesses are more likely to follow biodiversity initiatives. Moreover, when such efforts yield tangible advantages (whether financial or nonfinancial, such as mitigating future risks, reducing capital costs, generating long-term financial gains, enhancing the organization's reputation, and pro-



moting long-term value creation), these strengthen the case of integration into financial strategies. Hence, regulatory bodies and related stakeholders should focus on motivating businesses to adopt nature-positive practices based on these characteristics.

#### 4.2.4. Suggestion 4: Linking Business Profitability with Biodiversity Conservation

Addressing the challenges associated with biodiversity reporting requires adopting integrated reporting practices and utilizing external channels to ensure accountability [102]. Investors generally opt to allocate their funds to assets that ensure profits [103] while disregarding environmental information [104]. Stakeholders, such as investors, management, and creditors, can make informed decisions regarding policies when companies actively participate in environmental initiatives and transparently disclose these efforts in their annual reports [105]. A study by Moussa and Elmarzouky (2024b) on the impact of ESG disclosure on market uncertainty highlights the importance of ESG and carbon disclosures in improving market transparency and sustainability [106]. In the same way, we would like to suggest that biodiversity disclosure is also crucial for sustainable business practices.

However, obstructions to corporate environmental disclosure exist. This is because owners may prioritize retaining their share of profits over disclosing environmental information [107]. Nedopil (2022) contended that biodiversity considerations are not factored adequately into financial decision-making processes [103]. This is largely because of the absence of clear property rights for biodiversity and nature, whereby society sustains the negative externalities and the positive externalities remain difficult to quantify and are generally shared collectively. Therefore, he recommends the following four key principles: implementing regulations to regulate nature's exploitation, prioritizing the assessment and mitigation of the local biodiversity risks, leveraging the secondary advantages of biodiversity finance in conjunction with climate finance, and engaging financial decision makers to lead and champion biodiversity finance initiatives to reduce the finance and biodiversity disparity.

Introducing effective environmental accounting practices enhances a company's long-term financial viability and develops trust among investors and customers [108]. Implementing strategies for environmental conservation contributes to financial success in the long run and positively affects a company's reputation among key stakeholders. This would enhance its overall image and credibility [109]. An analysis by Daugaard (2019) of fund flows revealed the strong commitment of ESG investors [110]. The methodology devised by the Biodiversity Finance Initiative (BIOFIN) provides countries a systematic approach to monitor their spending on biodiversity [111]. A study by Moussa and Elmarzouky (2023) on nonfinancial firms listed on the FTSE (Financial Times Stock Exchange) has revealed that capital expenditure (capex) positively influences ESG disclosure, with firms which have higher governance quality showing greater ESG transparency after capex investments [112]. Additionally, this research suggest investors to take corporate governance into account since it may have an impact on the level of ESG disclosure following capital expenditures. The same theory can be applied to biodiversity disclosure, making it a prediction for the improvement of the biodiversity disclosure practices of the businesses. In particular, budget allocations that have an indirect impact on biodiversity are assigned a certain percentage to show their contribution to biodiversity outcomes. A study conducted by Seidl et al. (2020) on 30 selected countries revealed an increasing pattern in overall biodiversity spending in conjunction with an increase in the proportion of total public domestic investment allocated to biodiversity [113]. Garel et al. (2023) indicated that investors are increasingly demanding a risk premium because of the potential for future regulations or legal actions to protect biodiversity and suggests that investors are increasingly demanding a risk premium due to the potential for future regulations or legal actions for protecting biodiversity [114].

To expedite the advancement of biodiversity finance, it is essential to adopt a financial terminology that focuses on expenses (transactional costs), income, and potential hazards while discussing biodiversity [103]. Firms with greater exposure to biodiversity risk tend to increase their cash holdings, especially in industries highly exposed to such risks, facing

financial constraints, or high competition [115]. This behavior reflects a precautionary approach to managing biodiversity-related risks, separate from concerns about climate change risk. Impact investments are directed toward projects that produce tangible environmental or social advantages while also generating revenues that are returned to investors as financial gains. This return on investment could surpass, match, or fall below standard market rates [116]. Advanced participants in impact investing span various sectors and entities including institutional investors such as banks, pension funds, and insurance companies, as well as foundations, family offices, high-net-worth individuals, and development finance institutions such as the World Bank. Conventional and impact bonds play a significant role, because whether focused on safeguarding, restoring, or sustainably managing ecosystems and species, biodiversity conservation efforts generally encounter a shortage of funding [117]. In Peru, an impact bond was created to enhance the yield and sales of cocoa and coffee cultivated by indigenous communities. Although a few objectives were not achieved fully, the investors received approximately 65% of their initial investment. This revealed a positive outcome notwithstanding the challenges they encountered [117].

Green bonds operate similarly to conventional bonds. However, these have a distinctive feature, as follows: the funds raised by investors are dedicated only to supporting initiatives that yield positive environmental outcomes, such as renewable energy projects and sustainable building development [5]. The green bond market has developed into a distinct infrastructure within the capital markets. This infrastructure includes guidelines for green projects, commitments regarding the use of proceeds, external validation of green initiatives, and reporting mechanisms to ensure transparency and accountability [118]. In 2017, the Federal National Mortgage Association in the US issued USD 24.9 billion worth of green bonds. It represented 58% of the country's total green bond issuance. These bonds were connected to Fannie Mae's Multifamily Green Initiative. It aimed to improve the energy and water efficiency in apartment buildings and cooperatives. This initiative is a noteworthy example for EU authorities seeking private financing for similar projects including the installation of solar and water-saving irrigation systems in multifamily housing [119]. According to a case study in Sweden by Maltais and Nykvist (2020), engagement with the green bond market is primarily driven by nonfinancial incentives including attracting customers and staff and signaling a commitment to sustainability goals [118]. The financial sector's sustainability norms reinforce this engagement, with investors accepting lower returns and issuers undertaking additional efforts to issue green bonds.

By utilizing green bonds, funds raised from this type of debt instrument can be allocated directly to biodiversity projects. Simultaneously, this approach can reduce the interest rate associated with financing. These provide the dual advantages of environmental impact and cost efficiency (Figure 3). The existing literature shows the importance of a more robust and integrated approach to sustainability frameworks. The deficiencies identified in addressing environmental impacts, implementing biodiversity strategies, and leveraging standardized disclosures necessitate a critical reevaluation of current paradigms. The practical applications, industry commitment, and real impact on global sustainability goals require extensive research to advance effective progress in sustainable practices.

## 5. Conclusions

This study conducted a critical analysis of the challenges and prospects for enhancing biodiversity assessment in corporate sustainability frameworks. It emphasizes the importance of a standardized method for biodiversity disclosure and assessment. Studying sustainability reporting frameworks is important to identify the best approaches for addressing biodiversity-related issues. Existing sustainability frameworks, such as the GRI, SASB, TCFD, and TNFD, have incorporated disclosure standards for biodiversity impacts in different ways and at different levels. However, these existing frameworks should be modified further to support businesses in disclosing their biodiversity impacts. As an outlook, we refer to the new EU-related European Sustainability Reporting Standards (ESRS). These explicitly prescribe biodiversity and ecosystem accounting in detail in the

E4 standard. This regulation is particularly progressive. It would be applied to the EU for the first time in 2024. Therefore, a final assessment is still infeasible. Furthermore, the extent to which this regulation would become a global role model remains unclear [120]. However, to seamlessly disclose the impact of biodiversity, the development of a synchronized common-ground framework is essential. We provide four main suggestions to close these gaps. Using the GHG emissions methodology to evaluate the effect of biodiversity on business operations: Our suggestion is to implement a paradigm for assessing the biodiversity impact that is akin to the GHG emissions framework's Scopes 1, 2, and 3, which classify direct and indirect impacts on biodiversity along the supply chain.

The first recommendation is to develop a framework similar to that for disclosing carbon emissions that includes Scope 1 (direct impact by the business entity), Scope 2 (indirect impact in the supply chain), and Scope 3 (indirect impact through products/services). It can provide a comprehensive impact assessment rather than assessing upstream and downstream impacts. A more thorough understanding of the ecological consequences of enterprises is made possible by this organized framework, which enables them to systematically quantify and reveal their biodiversity footprint. This framework also supports more focused interventions. The second recommendation is that companies should consider focusing more on local biodiversity impacts that can be directly analyzed and controlled. Businesses should concentrate on reducing these local consequences through targeted conservation initiatives, since the effects of biodiversity frequently show at the local level. Businesses may reap actual environmental and reputational rewards by recognizing and mitigating biodiversity problems in their local operational areas. Taking examples from companies, Danone and Vale highlight the potential of localized biodiversity preservation to contribute positively to both business outcomes and environmental health.

The third recommendation is to improve sustainability recommendations and standards by focusing on the decision-making paradigm to bring corporate sector disclosures into an active decision-making step. Future frameworks should encourage companies to actively mitigate biodiversity impacts by embedding these considerations into their strategic planning and operational decisions, fostering a more proactive and sustainable approach to business. Recommendation 4 shows the importance of aligning profitability with biodiversity conservation by integrating environmental initiatives such as green bonds into corporate reporting practices. By integrating biodiversity considerations into financial decision making, businesses can enhance long-term value creation, reduce risks, and improve their reputation. Mechanisms such as green bonds and biodiversity finance offer opportunities for companies to align profitability with ecological sustainability, ensuring that businesses contribute to biodiversity conservation while benefiting from enhanced financial performance.

In addition to these recommendations, the role of government policies and regulatory frameworks is critical in ensuring the successful implementation of biodiversity disclosure practices. Standardized regulations, backed by scientific expertise, would provide the necessary structure for businesses to align their operations with biodiversity conservation goals.

Given the novelty of Suggestion 1 that we introduced in Section 3, we are unable to include relevant case studies as examples, which is a limitation of this study. Furthermore, the lack of empirical data to substantiate the suggestions are due to the absence of standardized biodiversity-related disclosures by most of the businesses. Future research should focus on the economic importance of biodiversity in financial decision making while concentrating on creating standardized methods for measuring biodiversity impacts throughout supply chains. Furthermore, studies should look into how policies and digital technologies might improve biodiversity disclosures and mitigation strategies.

**Author Contributions:** M.S., Writing—original draft, Writing—review and editing, and Visualization; I.H., Writing—review and editing, Conceptualization, and Visualization; G.D., Writing—review and editing, Conceptualization, and Visualization; S.L., Writing—review and editing and Conceptualization; J.H.R., Writing—review and editing, Conceptualization, and Visualization; Y.S.O., Writing—original draft, Writing—review and editing, Visualization, Resources, Supervision, Project

administration, Funding acquisition, and Conceptualization. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was supported by a National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT) (No. 2021R1A2C2011734). This research was also supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2021R1A6A1A10045235). This work was also supported by the Technology Innovation Program (Project No. 00432915, Development of biodegradable polymer and their applications using high-performance enzyme activation technologies for acceleration of biodegradability) funded By the Ministry of Trade, Industry & Energy (MOTIE, Korea) and the OJJeong Resilience Institute, Korea University.

**Data Availability Statement:** No new data were created or analyzed in this study. Data sharing is not applicable to this article.

**Conflicts of Interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. All statements made in this paper are the personal opinions of authors based on the research and have no relation with PricewaterhouseCoopers Consulting in any way.

## References

1. UNEP Global Biodiversity Outlook 5, Convention on Biological Diversity. 2020. Available online: <https://www.cbd.int/gbo5> (accessed on 15 January 2024).
2. Stork, N.E. Re-assessing current extinction rates. *Biodivers. Conserv.* **2009**, *19*, 357–371. [CrossRef]
3. Damiani, M.; Sinkko, T.; Caldeira, C.; Tosches, D.; Robuchon, M.; Sala, S. Critical review of methods and models for biodiversity impact assessment and their applicability in the LCA context. *Environ. Impact Assess. Rev.* **2023**, *101*, 107134. [CrossRef]
4. UNEP Facts about the Nature Crisis. UNEP—UN Environment Programme. 2023. Available online: [https://www.unep.org/facts-about-nature-crisis?gad\\_source=1&gclid=Cj0KCQiAn-2tBhDVARIsAGmStVkJ0Ndyf1aiP8u60imTI\\_2M58B8PUWBRAnXr-h11z1jbUMqR\\_G7AszlaAr\\_yEALw\\_wcB](https://www.unep.org/facts-about-nature-crisis?gad_source=1&gclid=Cj0KCQiAn-2tBhDVARIsAGmStVkJ0Ndyf1aiP8u60imTI_2M58B8PUWBRAnXr-h11z1jbUMqR_G7AszlaAr_yEALw_wcB) (accessed on 2 February 2024).
5. Global Risks Report 2024 | World Economic Forum. World Economic Forum. 12 January 2024. Available online: <https://www.weforum.org/publications/global-risks-report-2024/> (accessed on 4 February 2024).
6. Nature Positive Initiative. Nature Positive. 2023. Available online: <https://www.naturepositive.org/what-is-nature-positive/> (accessed on 17 August 2024).
7. IUCN in Convention on Biological Diversity (ISBN: No. 978-2-918105-42-8). 2014. Available online: <https://www.cbd.int/business/doc/IUCN-reporting.pdf> (accessed on 29 August 2024).
8. Dasgupta, P. Economics of Biodiversity: The Dasgupta Review. 2021. Available online: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/962785/The\\_Economics\\_of\\_Biodiversity\\_The\\_Dasgupta\\_Review\\_Full\\_Report.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962785/The_Economics_of_Biodiversity_The_Dasgupta_Review_Full_Report.pdf) (accessed on 25 January 2024).
9. Shanmukha, T.; Vinayaka, M.; Lokeshappa, B.; Nadaf, S. Biodiversity loss due to mining activities. In *Practice, Progress, and Proficiency in Sustainability*; IGI Global: Hershey, PA, USA, 2024; pp. 166–191. [CrossRef]
10. GRI (Global Reporting Initiative). Sustainability Reporting Standards: GRI 300: Disclosure on Biodiversity Impacts. GRI Website. 2020. Available online: <https://www.globalreporting.org/standards/gri-standards-download-center/> (accessed on 12 January 2024).
11. Kurth, T.; Wübbels, G.; Portafaix, A.; Felde AM, Z.; Zielcke, S. The Biodiversity Crisis Is a Business Crisis. Boston Consulting Group. 2021. Available online: <https://web-assets.bcg.com/fb/5e/74af5531468e9c1d4dd5c9fc0bd7/bcg-the-biodiversity-crisis-is-a-business-crisis-mar-2021-rr.pdf> (accessed on 22 March 2024).
12. Gazzo, A.; Bell, M. Why Biodiversity May Be More Important to Your Business Than You Realize. EY. 2022. Available online: [https://www.ey.com/en\\_gl/insights/assurance/why-biodiversity-may-be-more-important-to-your-business-than-you-realize](https://www.ey.com/en_gl/insights/assurance/why-biodiversity-may-be-more-important-to-your-business-than-you-realize) (accessed on 1 May 2024).
13. Zollo, M. Corporations Have Played a Key Role in the World’s Biodiversity Crisis. Now, Some Business Leaders Are Recognising This—And Making Amends. Imperial College Business School. 2023. Available online: <https://www.imperial.ac.uk/business-school/ib-knowledge/strategy-leadership/how-businesses-are-addressing-the-biodiversity-crisis/> (accessed on 24 August 2024).
14. Eccles, R.G.; Serafeim, G. The performance frontier: Innovating for a sustainable strategy. *Harv. Bus. Rev.* **2013**, *91*, 50–60. [PubMed]
15. Ermgassen, S.Z.; Howard, M.W.; Bennun, L.; Addison, P.; Bull, J.W.; Loveridge, R.; Pollard, E.; Starkey, M. Are corporate biodiversity commitments consistent with delivering ‘nature-positive’ outcomes? A review of ‘nature-positive’ definitions, company progress and challenges. *J. Clean. Prod.* **2022**, *379*, 134798. [CrossRef]
16. Abson, D.J.; Dougill, A.J.; Stringer, L.C.; Williams, P.; Adams, W.M. Socio-cultural values and ecosystem services: Insights from two communities in Panama. *Ecosyst. Serv.* **2017**, *25*, 51–63.

17. United Nations. The 17 Sustainable Development Goals. 2015. Available online: <https://sdgs.un.org/goals> (accessed on 2 January 2024).
18. TNFD (Task Force on Nature-Related Financial Disclosures). Interim Report: The Road to Meaningful Nature-Related Financial Disclosures. TNFD Website. 2021. Available online: <https://tnfd.info/interim-report/> (accessed on 2 January 2024).
19. Churchill, E. Environmental degradation and human well-being: Report of the millennium ecosystem assessment. *Popul. Dev. Rev.* **2005**, *31*, 389–398. [CrossRef]
20. Katic, P.; Cerretelli, S.; Haggard, J.; Santika, T.; Walsh, C. Mainstreaming biodiversity in business decisions: Taking stock of tools and gaps. *Biol. Conserv.* **2023**, *277*, 109831. [CrossRef]
21. Margaryan, L. 3. Lifestyle entrepreneurs as agents of degrowth: The case of nature-based tourism businesses in Scandinavia. In *Degrowth and Tourism. New Perspectives on Tourism Entrepreneurship, Destinations and Policy*; Routledge: Oxfordshire, UK, 2020.
22. NEE Biodiversity on the balance sheet. *Nat. Ecol. Evol.* **2023**, *7*, 1333. [CrossRef]
23. Taskforce on Nature-Related Financial Disclosures. Additional Guidance by Sector—TNFD. 2023. Available online: [https://tnfd.global/tnfd-publications/?\\_sft\\_framework-categories=additional-guidance-by-sector#search-filter](https://tnfd.global/tnfd-publications/?_sft_framework-categories=additional-guidance-by-sector#search-filter) (accessed on 29 January 2024).
24. Rudgley, G.; Seega, N. Handbook for Nature-Related Financial Risks: Key Concepts and a Framework for Identification. Cambridge Institute for Sustainability Leadership and Banking Environment Initiative. 2021. Available online: <https://www.cisl.cam.ac.uk/resources/sustainable-finance-publications/handbook-nature-related-financial-risks> (accessed on 15 March 2024).
25. Kedward, K.; Ryan-Collins, J.; Chenet, H. Biodiversity loss and climate change interactions: Financial stability implications for central banks and financial supervisors. *Clim. Policy* **2022**, *23*, 763–781. [CrossRef]
26. Finance for Biodiversity. Finance and Biodiversity: Overview of Initiatives for Financial Institutions. 2021. Available online: [https://www.financeforbiodiversity.org/wp-content/uploads/Finance\\_and\\_Biodiversity\\_Overview\\_of\\_Initiatives\\_April2021.pdf](https://www.financeforbiodiversity.org/wp-content/uploads/Finance_and_Biodiversity_Overview_of_Initiatives_April2021.pdf) (accessed on 2 January 2024).
27. Athanas, A. The role of business in biodiversity and impact assessment. *Impact Assess. Proj. Apprais.* **2005**, *23*, 29–35. [CrossRef]
28. Steffen, W.; Richardson, K.; Rockström, J.; Cornell, S.E.; Fetzer, I.; Bennett, E.M.; Biggs, R.; Carpenter, S.R.; De Vries, W.; De Wit, C.A.; et al. Planetary boundaries: Guiding human development on a changing planet. *Science* **2015**, *347*, 1259855. [PubMed]
29. Beck-O'Brien, M.; Bringezu, S. Biodiversity Monitoring in Long-Distance Food Supply Chains: Tools, gaps and needs to meet business requirements and sustainability goals. *Sustainability* **2021**, *13*, 8536. [CrossRef]
30. Kopnina, H.; Zhang, S.; Anthony, S.J.; Hassan, A.; Maroun, W. The inclusion of biodiversity into Environmental, Social, and Governance (ESG) framework: A strategic integration of ecocentric extinction accounting. *J. Environ. Manag.* **2024**, *351*, 119808. [CrossRef]
31. IBAT Integrated Biodiversity Assessment Tool (IBAT). 2024. Available online: <https://www.ibat-alliance.org/> (accessed on 2 September 2024).
32. Global Biodiversity Score: 2023 Update | CDC Biodiversité. 2023. Available online: [https://www.cdc-biodiversite.fr/publications/2024\\_dossier49-global-biodiversity-score-2023-update/](https://www.cdc-biodiversite.fr/publications/2024_dossier49-global-biodiversity-score-2023-update/) (accessed on 2 September 2024).
33. Kunming-Montreal Global Biodiversity Framework and Its Monitoring Framework. 28 February 2023. United Nations. Available online: [https://seea.un.org/sites/seea.un.org/files/unsc\\_presentation\\_jillian\\_campbell\\_0.pdf](https://seea.un.org/sites/seea.un.org/files/unsc_presentation_jillian_campbell_0.pdf) (accessed on 10 January 2024).
34. Lehmann, I. Inspiration from the Kunming-Montreal Global Biodiversity Framework for SDG 15. *Int. Environ. Agreem. Politics Law Econ.* **2023**, *23*, 207–214. [CrossRef]
35. Scarpellini, S.; Álvarez-Etxeberria, I. Trends in private sector engagement with biodiversity: EU listed companies' disclosure and indicators. *Ecol. Econ.* **2023**, *210*, 107864. [CrossRef]
36. Convention on Biological Diversity. Biodiversity Mainstreaming. 2023. Available online: <https://www.cbd.int/mainstreaming> (accessed on 17 August 2024).
37. Smith, J.; Bass, S.; Roe, D. Biodiversity Mainstreaming: A Review of Current Theory and Practice. ResearchGate. 2020. Available online: [https://www.researchgate.net/publication/347519511\\_Biodiversity\\_mainstreaming\\_A\\_review\\_of\\_current\\_theory\\_and\\_practice](https://www.researchgate.net/publication/347519511_Biodiversity_mainstreaming_A_review_of_current_theory_and_practice) (accessed on 17 August 2024).
38. Bubna-Litic, K. Mandatory Corporate Environmental Reporting: Does It Really Work? Chartered Secretaries Australia. 2004. Available online: <https://opus.lib.uts.edu.au/bitstream/10453/1474/1/2004000319.pdf> (accessed on 15 February 2024).
39. Vorhies, F. *Business & Biodiversity: The Handbook for Corporate Action*; World Conservation Union: Gland, Switzerland, 2002.
40. KPMG Global-Survey-of-Sustainability-Reporting-2022. 2022. Available online: <https://assets.kpmg.com/content/dam/kpmg/se/pdf/komm/2022/Global-Survey-of-Sustainability-Reporting-2022.pdf> (accessed on 19 August 2024).
41. Hassan, A.M.; Roberts, L.; Atkins, J. Exploring factors relating to extinction disclosures: What motivates companies to report on biodiversity and species protection? *Bus. Strategy Environ.* **2020**, *29*, 1419–1436. [CrossRef]
42. Huang, C.; Patsika, V.; Triantafylli, A.; Zhang, Y. Mandatory greenhouse gas emissions reporting and firm environmental litigation risk. *Account. Forum* **2023**, *47*, 249–277. [CrossRef]
43. Charitou, A. Discussion of “The Evolution of Environmental Reporting in Europe: The Role of Financial and Non-Financial Regulation”. *Int. J. Account.* **2022**, *57*, 2280003. [CrossRef]
44. Tang, S.; Demeritt, D. Climate change and mandatory carbon reporting: Impacts on business process and performance. *Bus. Strategy Environ.* **2017**, *27*, 437–455. [CrossRef]

45. Carungu, J.; Di Pietra, R.; Molinari, M. Mandatory vs voluntary exercise on non-financial reporting: Does a normative/coercive isomorphism facilitate an increase in quality? *Meditari Account. Res.* **2020**, *29*, 449–476. [CrossRef]
46. Bose, S. Evolution of ESG reporting frameworks. In *Values at Work*; Palgrave Macmillan: Cham, Switzerland, 2020; pp. 13–33. [CrossRef]
47. Chofreh, A.G.; Goni, F.A. Review of Frameworks for Sustainability Implementation. *Sustain. Dev.* **2017**, *25*, 180–188. [CrossRef]
48. In, S.Y.; Lee, Y.J.; Eccles, R.G. Looking back and looking forward: A scientometric analysis of the evolution of corporate sustainability research over 47 years. *Corp. Soc. Responsib. Environ. Manag.* **2023**, *31*, 2225–2259. [CrossRef]
49. Ögren, M. The Journey of Accounting for Nature: A Qualitative Study of the Strive to Account for Nature through Translation of the TNFD Framework from a Scandinavian Institutionalism Perspective. 29 June 2023. Available online: <https://hdl.handle.net/2077/77543> (accessed on 20 March 2024).
50. GRI—Mission & History. globalreporting.org. 2024. Available online: <https://www.globalreporting.org/about-gri/mission-history/#:~:text=GRI%20was%20founded%20in%20Boston,of%20the%20UN%20Environment%20Programme> (accessed on 7 January 2024).
51. Goswami, K.; Islam, M.; Evers, W. A case study on the blended reporting phenomenon: A Comparative analysis of Voluntary Reporting Frameworks and Standards—GRI, IR, SASB, and CDP. *Int. J. Sustain. Policy Pract.* **2023**, *19*, 35–64. [CrossRef]
52. CDP. 2023. Available online: [https://www.cdp.net/en/?cid=315908478&adgpid=55107277875&itemid=&targid=kwd-354748248400&mt=b&loc=9197530&ntwk=g&dev=c&dmod=&adp=&gad\\_source=1&gclid=CjwKCAjwreW2BhBhEiwAavLwfpPw-evIb0Ve-3L-qHPsZoUgBUGANSfadsNuZKPjsjFpo9b5JCulhoC46sQAvD\\_BwE](https://www.cdp.net/en/?cid=315908478&adgpid=55107277875&itemid=&targid=kwd-354748248400&mt=b&loc=9197530&ntwk=g&dev=c&dmod=&adp=&gad_source=1&gclid=CjwKCAjwreW2BhBhEiwAavLwfpPw-evIb0Ve-3L-qHPsZoUgBUGANSfadsNuZKPjsjFpo9b5JCulhoC46sQAvD_BwE) (accessed on 1 September 2024).
53. Goswami, K.; Islam, M.K.; Evers, W. Aspire to Attaining Sustainability? Let's Understand Contemporary Sustainability or ESG Frameworks. In *The Blue Planet—A Magazine on Sustainability*; ACS/DRIP—Knowledge Press: Adelaide, Australia, 2022; Volume 4.
54. GHG Protocol. 9 February 2024. Available online: <https://ghgprotocol.org/about-us> (accessed on 4 February 2024).
55. SASB Standards. Sustainability Accounting Standards Board. 2023. Available online: <https://sasb.org/standards/materiality-finder/> (accessed on 16 January 2024).
56. IFC Understanding the Global Reporting Frameworks | Beyond the Balance Sheet. 2023. Available online: <https://www.ifcbeyondthebalancesheet.org/understanding-global-reporting-frameworks> (accessed on 28 January 2024).
57. Integrated Reporting Framework | Integrated Reporting. 2022. Available online: <https://integratedreporting.ifrs.org/resource/international-ir-framework/> (accessed on 28 January 2024).
58. O'Dwyer, B.; Unerman, J. Shifting the focus of sustainability accounting from impacts to risks and dependencies: Researching the transformative potential of TCFD reporting. *Account. Audit. Account.* **2020**, *33*, 1113–1141. [CrossRef]
59. Jona, J.; Soderstrom, N.S. Evolution of climate-related disclosure guidance and application of climate risk measurement in research. In *Handbook of Accounting and Sustainability*; Edward Elgar Publishing: Cheltenham, UK, 2022; pp. 397–420. [CrossRef]
60. Carney, M. TCFD: Strengthening the foundations of sustainable finance. In *Proceedings of the TCFD Summit*; SUERF (The European Money and Finance Forum): Vienna, Austria, 2019.
61. Nascimento, L.; Kuramochi, T.; Iacobuta, G.; Elzen, M.D.; Fekete, H.; Weishaupt, M.; Van Soest, H.L.; Roelfsema, M.; De Vivero-Serrano, G.; Lui, S.; et al. Twenty years of climate policy: G20 coverage and gaps. *Clim. Policy* **2021**, *22*, 158–174. [CrossRef]
62. Fyson, C.; Hare, B.; Lissner, T.; Ancygier, A.; Attard, M.-C.; Hörsch, J. G7 Climate Policy: What Good Looks Like. In *Climate Analytics*. 2022. Available online: [https://ca1-clm.edcdn.com/assets/g7\\_climate\\_policy\\_-\\_what\\_good\\_looks\\_like.pdf](https://ca1-clm.edcdn.com/assets/g7_climate_policy_-_what_good_looks_like.pdf) (accessed on 18 August 2024).
63. Andrew, J.; Cortese, C. Accounting for climate change and the self-regulation of carbon disclosures. *Account. Forum* **2011**, *35*, 130–138.
64. Deweerdt, T.; Caltabiano, K.; Dargusch, P. Original research: How will the TNFD impact the health sector's Nature-Risks management? *Int. J. Environ. Res. Public Health* **2022**, *19*, 13345. [CrossRef]
65. Global Sustainability Standards Board GRI 3: Material Topics 2021. 2023. Available online: <https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-english-language/> (accessed on 27 January 2024).
66. McKean-Wood, N.; Gaussem, J.; Hanks, J. *Forging a Path to Integrated Reporting*; GRI: Amsterdam, The Netherlands, 2016; Available online: [https://integratedreportingsa.org/ircsa/wp-content/uploads/2017/05/GRICLG\\_IntegratedReporting.pdf](https://integratedreportingsa.org/ircsa/wp-content/uploads/2017/05/GRICLG_IntegratedReporting.pdf) (accessed on 16 May 2024).
67. Sustainability Accounting Standards Board. Companies Reporting with SASB Standards. *SASB*. 2020. Available online: <https://www.sasb.org/company-use/sasb-reporters/> (accessed on 28 January 2024).
68. The Essential ESG Toolkit: Bloomberg Law: Comparison Table: ESG Frameworks. Bloomberg Law 2022. Available online: <https://pro.bloomberglaw.com> (accessed on 15 January 2024).
69. Busco, C.; Consolandi, C.; Eccles, R.G.; Sofra, E. A preliminary analysis of SASB reporting: Disclosure topics, financial relevance, and the financial intensity of ESG materiality. *J. Appl. Corp. Financ.* **2020**, *32*, 117–125. [CrossRef]
70. Task Force on Climate-related Financial Disclosures: Implementing the Recommendations of the Task Force on Climate-Related Financial Disclosures. TCFD. October 2021. Available online: [https://assets.bbhub.io/company/sites/60/2021/07/2021-TCFD-Implementing\\_Guidance.pdf](https://assets.bbhub.io/company/sites/60/2021/07/2021-TCFD-Implementing_Guidance.pdf) (accessed on 16 January 2024).
71. Cooper, S.; Michelon, G. Conceptions of materiality in sustainability reporting frameworks: Commonalities, differences and possibilities. In *Handbook of Accounting and Sustainability*; Edward Elgar Publishing: Cheltenham, UK, 2022; pp. 44–66. [CrossRef]

72. CDP and Environmental Disclosure Standards and Frameworks—CDP. 2021. Available online: <https://www.cdp.net/en/guidance/environmental-disclosure-standards-and-frameworks> (accessed on 27 January 2024).
73. GRI 304: BIODIVERSITY 2016. Global Reporting. 2018. Available online: <https://wapsustainability.com/wp-content/uploads/2020/11/gri-304-biodiversity.pdf> (accessed on 16 January 2024).
74. Disclosing through CDP: The Business Benefits. CDP. 2023. Available online: [https://cdn.cdp.net/cdp-production/comfy/cms/files/files/000/007/896/original/Benefits\\_of\\_Disclosure\\_brochure\\_2023.pdf](https://cdn.cdp.net/cdp-production/comfy/cms/files/files/000/007/896/original/Benefits_of_Disclosure_brochure_2023.pdf) (accessed on 16 January 2024).
75. Guthrie, J.; Abeysekera, I. Content analysis of social, environmental reporting: What is new? *J. Hum. Resour. Costing Account.* **2006**, *10*, 114–126. [CrossRef]
76. West, P. Companies Struggle to Digest ‘Alphabet Soup’ of ESG Arbiters. *Financial Times*. 6 October 2019. Available online: <https://www.ft.com/content/b9bdd50c-f669-3f9c-a5f4-c2cf531a35b5> (accessed on 6 October 2019).
77. IFRS—General Sustainability-Related Disclosures. 2023. Available online: <https://www.ifrs.org/projects/completed-projects/2023/general-sustainability-related-disclosures/> (accessed on 5 February 2024).
78. Negash, M. IFRS and environmental accounting. *Manag. Res. Rev.* **2012**, *35*, 577–601. [CrossRef]
79. Purvis, A.; Héctor, A. Getting the measure of biodiversity. *Nature* **2000**, *405*, 212–219. [CrossRef] [PubMed]
80. Bishop, J.; Kapila, S.; Hicks, F.; Mitchell, P.; Vorhies, F. New business models for biodiversity conservation. *J. Sustain. For.* **2009**, *28*, 285–303. [CrossRef]
81. Boiral, O.; Saizarbitoria, I.H.; Brotherton, M. Assessing and improving the quality of sustainability Reports: The Auditors’ perspective. *J. Bus. Ethics* **2017**, *155*, 703–721. [CrossRef]
82. Roberts, L.; Hassan, A.; Elamer, A.A.; Nandy, M. Biodiversity and extinction accounting for sustainable development: A systematic literature review and future research directions. *Bus. Strategy Environ.* **2020**, *30*, 705–720. [CrossRef]
83. Addison, P.; Bull, J.W.; Milner-Gulland, E.J. Using conservation science to advance corporate biodiversity accountability. *Conserv. Biol.* **2018**, *33*, 307–318. [CrossRef]
84. Hurley, L.; Ashley, R.; Mounce, S.R. Addressing practical problems in sustainability assessment frameworks. *Proc. Inst. Civ. Eng.* **2008**, *161*, 23–30. [CrossRef]
85. Marshall, J.; Toffel, M.W. Framing the Elusive Concept of Sustainability: A Sustainability Hierarchy. *Environ. Sci. Technol.* **2004**, *39*, 673–682. [CrossRef]
86. Layman, H.; Akçakaya, H.R.; Irwin, A.; Ermgassen, S.Z.; Addison, P.; Burgman, M.A. Short-term solutions to biodiversity conservation in portfolio construction: Forward-looking disclosure and classification-based metrics biodiversity conservation in portfolio construction. *Bus. Strategy Environ.* **2024**, *33*, 1778–1793. [CrossRef]
87. Lähtinen, K.; Guan, Y.; Li, N.; Toppinen, A. Biodiversity and ecosystem services in supply chain management in the global forest industry. *Ecosyst. Serv.* **2016**, *21*, 130–140. [CrossRef]
88. Houdet, J.; Trommetter, M.; Wéber, J. Understanding changes in business strategies regarding biodiversity and ecosystem services. *Ecol. Econ.* **2012**, *73*, 37–46. [CrossRef]
89. Mair, L.; Elnahass, M.; Xiang, E.; Hawkins, F.; Siikamaki, J.; Hillis, L.; Barrie, S.; McGowan, P.J.K. Corporate disclosures need a biodiversity outcome focus and regulatory backing to deliver global conservation goals. *Conserv. Lett.* **2024**, *17*, e13024. [CrossRef]
90. Boiral, O. Sustainability reports as simulacra? A counter-account of A and A+ GRI reports. *Account. Audit. Account.* **2013**, *26*, 1036–1071. [CrossRef]
91. Winter, L.; Lehmann, A.; Finogenova, N.; Finkbeiner, M. Including biodiversity in life cycle assessment—State of the art, gaps and research needs. *Environ. Impact Assess. Rev.* **2017**, *67*, 88–100. [CrossRef]
92. Rankin, D.J.; Bargum, K.; Kokko, H. The tragedy of the commons in evolutionary biology. *Trends Ecol. Evol.* **2007**, *22*, 643–651. [CrossRef] [PubMed]
93. Ramanathan, V.; Feng, Y. Air pollution, greenhouse gases and climate change: Global and regional perspectives. *Atmos. Environ.* **2009**, *43*, 37–50. [CrossRef]
94. Newbold, T.; Hudson, L.N.; Hill, S.L.; Contu, S.; Lysenko, I.A.R.; Senior Börger, L.; Bennett, D.J.; Choimes, A.; Collen, B.; Day, J.; et al. Global effects of land use on local terrestrial biodiversity. *Nature* **2015**, *520*, 45–50. [CrossRef] [PubMed]
95. Sustainability | Samsung Electronics. 2023. Available online: <https://www.samsung.com/global/sustainability/> (accessed on 3 September 2024).
96. Mason, A.R.; Puchol-Salort, P.; Gathorne-Hardy, A.; Smith, B.M.; Myers, R.J. Local terrestrial biodiversity impacts in life cycle assessment: A case study of sedum roofs in London, UK. *J. Ind. Ecol.* **2024**, *28*, 496–511. [CrossRef]
97. Aladağ, Ö.F. Integrating Biodiversity into Business Strategy: Theoretical Foundations and Exemplary Cases. *İktisadi İdari Ve Siyasal Araştırmalar Derg.* **2023**, *8*, 782–794. [CrossRef]
98. Gastauer, M.; Pinheiro, T.; Caldeira, C.F.; Ramos, S.J.; Coelho, R.R.; Fonseca, D.S.; Tyski, L.; De Rezende Cardoso, A.L.; De Sá Carvalho Neto, C.; Guimarães, L.; et al. Large-scale forest restoration generates comprehensive biodiversity gains in an Amazonian mining site. *J. Clean. Prod.* **2024**, *443*, 140959. [CrossRef]
99. Thomsen, M.S.; Garcia, C.; Bolam, S.G.; Parker, R.P.; Godbold, J.A.; Solan, M. Consequences of biodiversity loss diverge from expectation due to post-extinction compensatory responses. *Sci. Rep.* **2017**, *7*, 43695. [CrossRef]
100. Mintah, E.O.; Elmarzouky, M. Digital-Platform-Based Ecosystems: CSR Innovations during Crises. *J. Risk Financ. Manag.* **2024**, *17*, 247. [CrossRef]

101. Al-Waeli, A.J.; Khalid, A.A.; Ismail, Z.; Idand, H.Z. The Relationship between Environmental Disclosure and Financial Performance of Industrial companies with Using a New Theory: Literature Review. *J. Contemp. Issues Bus. Gov.* **2021**, *27*, 3846–3868.
102. Venturelli, A.; Ligorio, L.; De Nuccio, E. Biodiversity accountability in water utilities: A case study. *Util. Policy* **2023**, *81*, 101495. [[CrossRef](#)]
103. Nedopil, C. Integrating biodiversity into financial decision-making: Challenges and four principles. *Bus. Strategy Environ.* **2022**, *32*, 1619–1633. [[CrossRef](#)]
104. Choi, D.; Gao, Z.; Jiang, W. Attention to Global Warming. 2020. Available online: [https://econpapers.repec.org/article/ouprfnst/v\\_3a33\\_3ay\\_3a2020\\_3ai\\_3a3\\_3ap\\_3a1112-1145.html](https://econpapers.repec.org/article/ouprfnst/v_3a33_3ay_3a2020_3ai_3a3_3ap_3a1112-1145.html) (accessed on 25 January 2024).
105. Hertati, L.; Puspitawati, L.; Gantino, R.; Ilyas, M. The Sales Volume and Operating Costs as Key Influencing Factors in Covid-19 Pandemic Era. *Glob. J. Account. Econ. Res.* **2022**, *3*, 83–105.
106. Moussa, A.S.; Elmarzouky, M. Sustainability Reporting and Market Uncertainty: The Moderating Effect of carbon Disclosure. *Sustainability* **2024**, *16*, 5290. [[CrossRef](#)]
107. Gerged, A.M. Factors affecting corporate environmental disclosure in emerging markets: The role of corporate governance structures. *Bus. Strategy Environ.* **2020**, *30*, 609–629. [[CrossRef](#)]
108. Kholmi, M.; Nafiza, S.A. Pengaruh Penerapan Green Accounting dan Corporate Social Responsibility Terhadap Profitabilitas (Studi Pada Perusahaan Manufaktur Yang Terdaftar di BEI Tahun 2018–2019). *Reviu Akunt. Dan Bisnis Indones.* **2022**, *6*, 143–155. [[CrossRef](#)]
109. Susanti, I.D.; Hertati, L.; Putri, A.U. The Effect of Green Accounting and Environmental Performance on Company Profitability. *Cashflow Curr. Adv. Res. Sharia Financ. Econ. Worldw.* **2023**, *2*, 320–331. [[CrossRef](#)]
110. Daugaard, D. Emerging new themes in environmental, social and governance investing: A systematic literature review. *Account. Financ.* **2019**, *60*, 1501–1530. [[CrossRef](#)]
111. BIOFIN. 2021. Available online: <https://www.biofin.org/> (accessed on 2 March 2024).
112. Moussa, A.S.; Elmarzouky, M. Does capital expenditure matter for ESG disclosure? A UK perspective. *J. Risk Financ. Manag.* **2023**, *16*, 429. [[CrossRef](#)]
113. Seidl, A.; Mulungu, K.; Arlaud, M.; Van Den Heuvel, O.; Riva, M. Finance for nature: A global estimate of public biodiversity investments. *Ecosyst. Serv.* **2020**, *46*, 101216. [[CrossRef](#)]
114. Garel, A.; Romec, A.; Sautner, Z.; Wagner, A.F. Do Investors Care about Biodiversity? Available online: [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=4398110](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4398110) (accessed on 3 September 2024).
115. Ahmad, M.F.; Karpuz, A. Beyond climate change risk: Biodiversity and corporate cash holdings. *Econ. Lett.* **2024**, *236*, 111608. [[CrossRef](#)]
116. Trelstad, B. Impact Investing: A Brief History. 1 December 2016. Available online: <https://ssrn.com/abstract=2886088> (accessed on 12 February 2024).
117. Belt, J.; Kuleshov, A.; Minneboo, E. Development impact bonds: Learning from the Asháninka cocoa and coffee case in Peru. *Enterp. Dev. Microfinance* **2017**, *28*, 130–144. [[CrossRef](#)]
118. Maltais, A.; Nykvist, B. Understanding the Role of Green Bonds in Advancing Sustainability. Available online: <https://www.tandfonline.com/doi/full/10.1080/20430795.2020.1724864#abstract> (accessed on 3 September 2024).
119. Bhutta, U.S.; Tariq, A.; Farrukh, M.; Raza, A.; Iqbal, M.K. Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technol. Forecast. Soc. Chang.* **2022**, *175*, 121378.
120. Jonkman, M. ESRS E4: Biodiversity and Ecosystems. 30 November 2023. Available online: <https://www.linkedin.com/pulse/esrs-e4-biodiversity-ecosystems-maya-jonkman-kulyabina--oda5f/> (accessed on 15 July 2024).

**Disclaimer/Publisher’s Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.