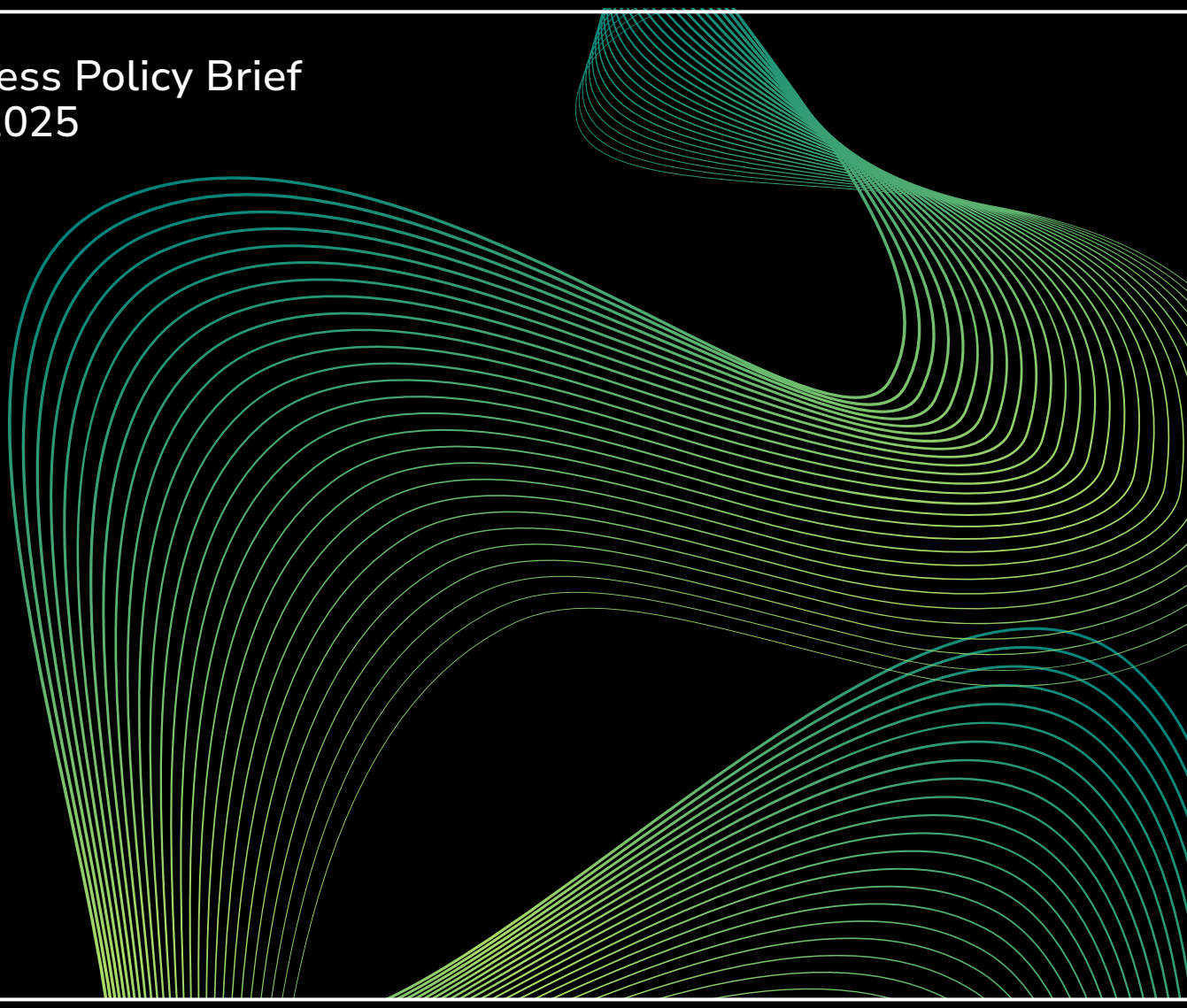
RAIN FOREST

Quantifying climate and biodiversity footprints of companies and investment portfolios

Business Policy Brief
May 2025



Authors: Hanzhong Zheng, Koen J.J. Kuipers, Zengkai Zhang, Yuxuan Zhang, Mark A.J. Huijbregts, Michal Kulak

This project is funded bu the European Union's Horizon Europe research and innovation programme under agreements no. 10108744

Author list

Hanzhong Zheng
Department of Environmental Science, Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen, The Netherlands

Koen J.J. Kuipers
Department of Environmental Science, Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen, The Netherlands

Zengkai Zhang
State Key Laboratory of Marine Environmental Sciences, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian, China

Yuxuan Zhang
State Key Laboratory of Marine Environmental Sciences, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian, China

Mark A.J. Huijbregts
Department of Environmental Science, Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen, The Netherlands
Department of Circularity & Sustainability Impacts, TNO, Utrecht, The Netherlands

Michal Kulak
Robeco, Zürich, Switzerland

Background

Climate change and biodiversity loss are major environmental challenges that society faces[1,2]. Companies have great potential to mitigate climate change and biodiversity loss[3-5]. The European Union introduced the Corporate Sustainability Reporting Directive (CSRD) in 2023, mandating large companies to report the environmental risks and environmental impacts[6].While large companies disclose direct (scope 1) and energy-related (scope 2) greenhouse gas (GHG) emissions, indirect value-chain emissions (scope 3) are inconsistently reported, even though they typically represent the largest share of total company GHG footprints[7]. Disclosure of biodiversity footprints is even more limited and lacks standardization[8].

We developed a novel framework, based on EXIOBASE input-output analysis[9], to assess the GHG and biodiversity footprints of individual companies and of the whole MSCI All Country World Index (ACWI), which covers about 85% of the global investable equity.

Sector average GHG and biodiversity footprint intensities

GHG and biodiversity footprint intensities vary considerably across economic sectors (Fig. 1). Sectors such as coal mining (COL), distribution and trade of electricity (DTE), non-metallic mineral products (NMM), gas manufacture and distribution (GAS), and metal production (MET) have the highest GHG footprint intensities. These sectors are either directly involved in energy production and distribution or represent energy-intensive heavy industries. The agricultural (AGR), food production meat (FDM), seafood (SEA), dairy products (DAI), and paper products (PAP) sectors, have the highest biodiversity footprints, primarily via land use impacts.

Fig. 1 | **Sectoral intensity of GHG and biodiversity footprints averaged across MSCI ACWI companies within each sector.** a, GHG footprint intensity (tonnes CO_2-eq per million euro) by sector. b, Biodiversity footprint intensity (MSA-loss · km^2 per million euro) by sector.

Scope 3 impacts dominate across the value chain

More than 60% of GHG and biodiversity footprints occur upstream or downstream in the value chain (scope 3; Fig. 2a). Oil and gas mining and chemical products exhibit high levels of direct GHG footprints, primarily due to the extraction and refining of fossil fuels. They also cause direct biodiversity footprints due to mining activities. In contrast, the financial intermediation and wholesale and retail trade sectors have low direct and high indirect environmental footprints.

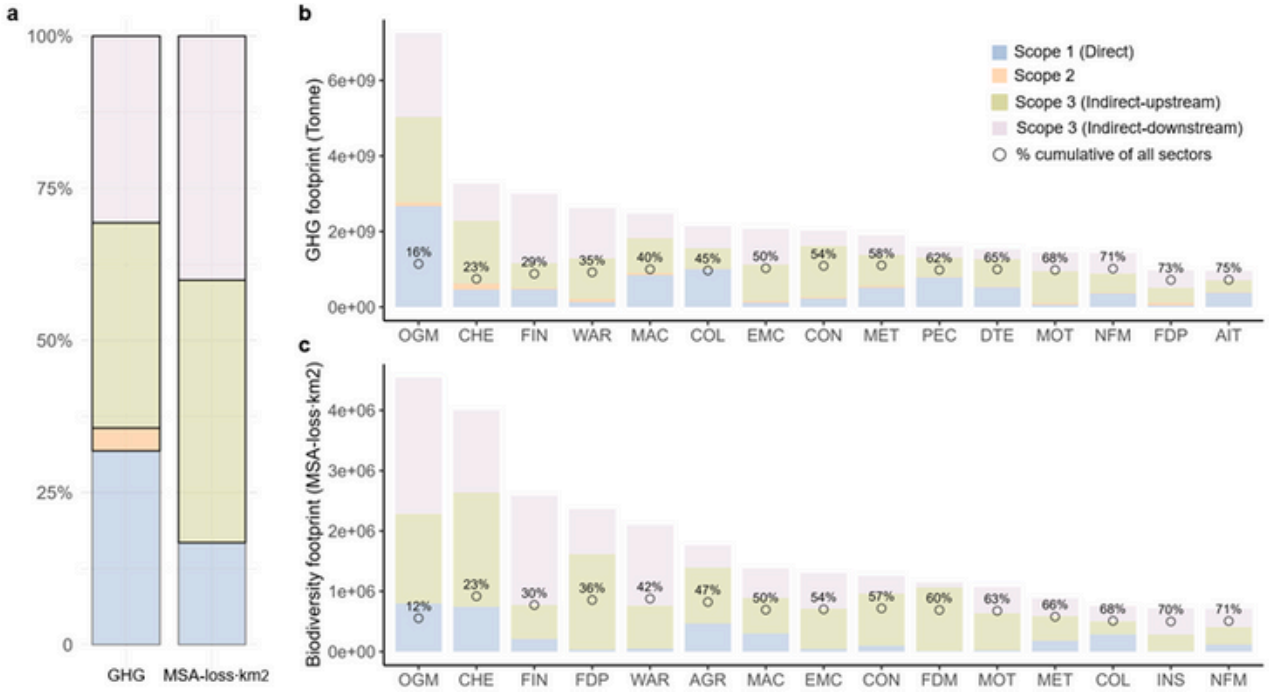


Fig. 2 | **GHG and biodiversity footprints of MSCI ACWI companies by sector.** a, Share of total GHG and biodiversity footprints by scope. b, Top 15 sectors with the highest GHG footprint. c, Top 15 sectors with the highest biodiversity footprint. The circle indicates the cumulative percentage contribution across all sectors.

A small number of companies drive a large share of impacts

As shown in Fig. 3, both GHG and biodiversity footprints are highly concentrated among a relatively small number of companies within the MSCI ACWI. The top 100 highest-impacting companies account for 55-59% of total GHG and biodiversity footprints. The top 100 companies are responsible for more than half of total footprints across direct (scope 1) and indirect (scope 2 & 3) categories for both GHG (Fig. 3b) and biodiversity footprints (Fig. 3d).

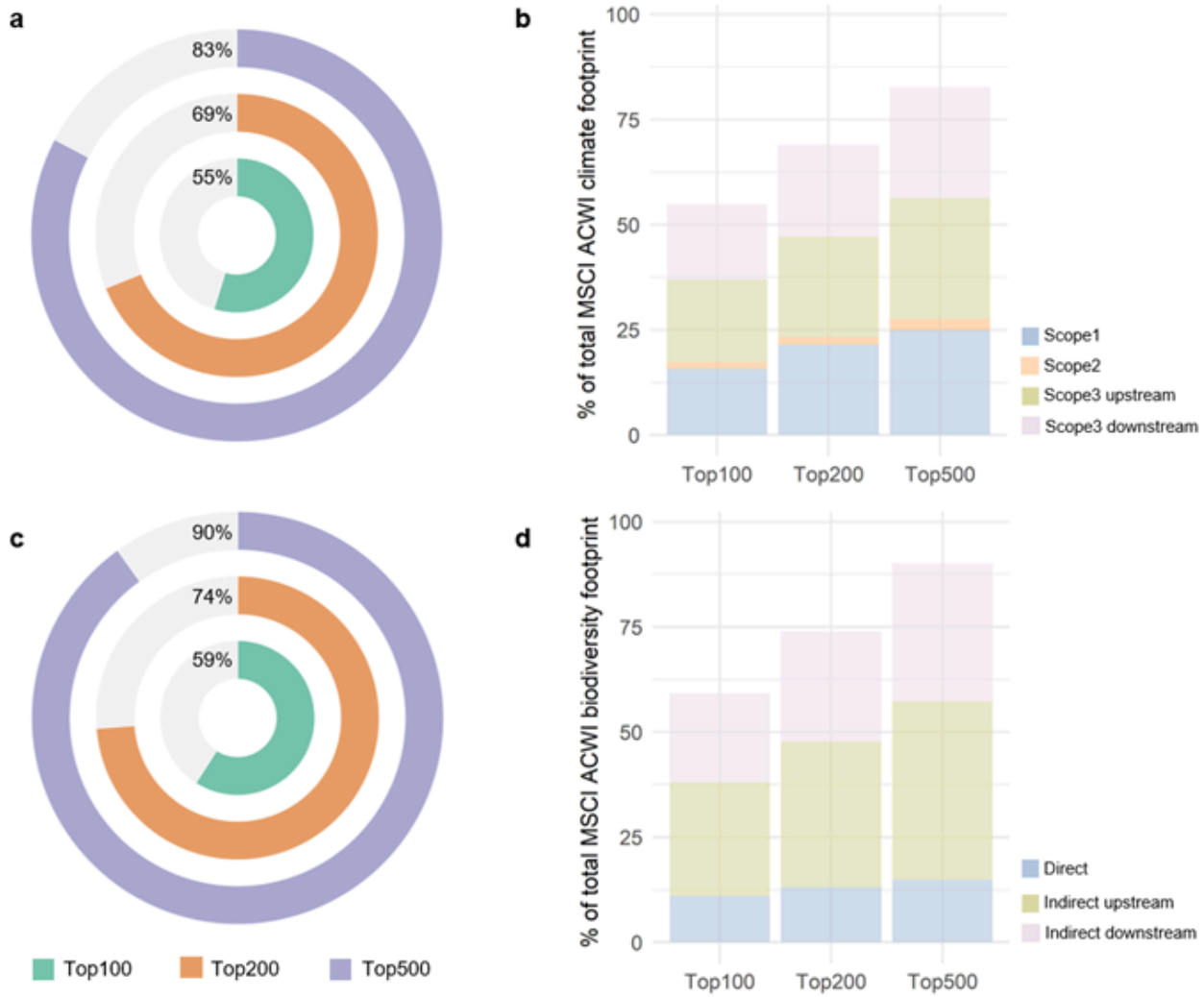


Fig. 3 | **Share of GHG and biodiversity footprints by top emitting companies in MSCI ACWI. a**, **b**, GHG footprint (**a**) and scope share (**b**) of the top 100, 200, and 500 companies compared to total MSCI ACWI climate footprint. **c**, **d**, Biodiversity footprint (**c**) and scope share (**d**) of the top 100, 200, and 500 companies compared to total MSCI ACWI biodiversity footprint.

Recommendations

“A small number of companies account for a disproportionate share of total environmental footprints.”

Under the CSRD, companies are required to disclose environmental impacts of their activities, with climate change and biodiversity loss as two of the most important domains. Given the complex interlinkages across sectors, a company’s environmental footprint extends well beyond its direct operations to its entire value chain[10,11].

Our findings emphasize the importance of scope 3 impacts, which dominate in most sectors yet remain underreported in many environmental assessments[12]. These indirect impacts highlight the need to consider environmental footprints across the entire supply chain rather than focusing solely on direct impacts.

A small number of companies account for a disproportionate share of total environmental footprints. Prioritizing these companies for engagement and targeted regulatory interventions could be an effective way to achieve transformative change for climate and biodiversity. Understanding the environmental footprint of investment portfolios, such as the MSCI ACWI, can help asset managers and financial institutions align capital flows with climate and biodiversity targets.

References

1. Newbold, T., Oppenheimer, P., Etard, A. & Williams, J. J. Tropical and Mediterranean biodiversity is disproportionately sensitive to land-use and climate change. Nat Ecol Evol 4, 1630–1638 (2020).
2. Pörtner, H. O. et al. Overcoming the coupled climate and biodiversity crises and their societal impacts. Science vol. 380 Preprint at https://doi.org/10.1126/science.abl4881 (2023).
3. Cenci, S., Burato, M., Rei, M. & Zollo, M. The alignment of companies' sustainability behavior and emissions with global climate targets. Nat Commun 14, (2023).
4. Kılkış, Ş. et al. City–company collaboration towards aligned science-based target setting. Nat Sustaindoi:10.1038/s41893-024-01473-w. (2024).
5. Etzion, D. Corporate engagement with the natural environment. Nature Ecology and Evolution vol. 4 493 Preprint at https://doi.org/10.1038/s41559-020-1142-5 (2020).
6. European Commission. DIRECTIVE (EU) 2022/2464 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting (CSRD). (2022).
7. GHG Protocol. A Corporate Accounting and Reporting Standard. (2002).
8. Kareiva, P. M., Mcnally, B. W., Mccormick, S., Miller, T. & Ruckelshaus, M. Improving global environmental management with standard corporate reporting. Proc. Natl Acad. Sci. USA 112, 7375–7382 (2015).
9. Stadler, K. et al. EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables. J Ind Ecol 22, 502–515 (2018).
10. Zhang, Z., Li, J., Wang, X., Chen, X. & Zheng, C. Leading global asset managers are crucial but off track in climate change mitigation. One Earth 101267. (2025).
11. Popescu, I. S., Schaubroeck, T., Gibon, T., Petucco, C. & Benetto, E. Investment funds are responsible for substantial environmental and social impacts. Commun Earth Environ 5, (2024).
12. Klaaßen, L. & Stoll, C. Harmonizing corporate carbon footprints. Nat Commun 12, (2021).

ABOUT RAINFOREST HEU

Food and biomass production systems are among the most prominent drivers of biodiversity loss worldwide. Halting and reversing the loss of biodiversity therefore requires transformative change of food and biomass systems, addressing the nexus of agricultural production, processing and transport, retailing, consumer preferences and diets, as well as investment, climate action and ecosystem conservation and restoration. The RAINFOREST project will contribute to enabling, upscaling and accelerating transformative change to reduce biodiversity impacts of major food and biomass value chains. Together with stakeholders, we will co-develop and evaluate just and viable transformative change pathways and interventions. We will identify stakeholder preferences for a range of policy and technology-based solutions, as well as governance enablers, for more sustainable food and biomass value chains. We will then evaluate these pathways and solutions using a novel combination of integrated assessment modelling, input-output modelling and life cycle assessment, based on case studies in various stages of the nexus, at different spatial scales and organizational levels. This coproduction approach enables the identification and evaluation of just and viable transformative change leverage points, levers and their impacts for conserving biodiversity (SDGs 12, 14-15) that minimize trade-offs with targets related to climate (SDG13) and socioeconomic developments (SDGs 1-3). We will elucidate leverage points, impacts, and obstacles for transformative change and provide concrete and actionable recommendations for transformative change for consumers, producers, investors, and policymakers.

PARTNERS