



# Climate-related prudential regulation: emerging perspectives and policy implications

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This article reviews the literature on climate-related prudential regulation, identifying the most relevant articles published in the last two years. The study is situated within the recent developments of this regulation in the United States and the European Union, given the high concentration of Global Systemically Important Banks in these regions. Through this critical analysis, five emerging perspectives have been identified: compensation policy, biodiversity loss, financed emissions, systemic risk, and sustainability taxonomies. The policy implications shed light on the proliferation of voluntary initiatives that may divert from climate goals, and highlight the need for a guided transition through harmonized regulation.

## Addresses

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**Current Opinion in Environmental Sustainability** 2024, **67**:101410

This review comes from a themed issue on **Climate Finance, Risks and Accounting**

Edited by **Rosella Carè, Othmar Lehner and Olaf Weber**

For complete overview of the section, please refer to the article collection, "[Climate Finance, Risks and Accounting](#)"

Available online 12 January 2024

Received: 15 September 2023; Revised: 4 December 2023; Accepted: 15 December 2023

<https://doi.org/10.1016/j.cosust.2023.101410>

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## Introduction

Despite advances in emission reduction, we are still a long way from achieving climate goals. To give an idea of the magnitude of the challenge, Friedlingstein et al. [1••] estimate, with a 50% probability, that the remaining carbon budget needed to keep global warming below 1.5°C will be consumed in only nine years at the 2022 emission rate. Considering a 2°C reduction, the budget horizon is 30 years. Furthermore, achieving net-zero carbon emissions by 2050 will require an annual reduction in CO<sub>2</sub> comparable to the decline observed

during the COVID-19 pandemic in 2020. The devastating fires of 2023 are one of the 'black swan' events that create a positive feedback loop, further narrowing this window of opportunity.

The impact of climate risks on banks can manifest through the depreciation of collateral or the default of their clients, which, in turn, have a direct effect on its balances. This is more evident in banks that hold assets concentrated in sectors exposed to these risks, such as buildings in areas prone to physical risks or assets related to fossil fuel production, which can become stranded assets. Therefore, it is crucial to avoid undervaluation of assets at risk to prevent a systemic situation similar to the subprime crisis of 2007-2008.

Academic research plays a fundamental role in advancing knowledge in this area. Some studies analyze the actions taken by central banks in various countries [2–7], while others focus on examining the advantages and disadvantages of climate risk tools [8–10]. Furthermore, some researchers have proposed regulatory frameworks for including them in banking [11,12], and a recent review has attempted to systematize the state-of-the-art and research gaps in the field of climate-related prudential regulation tools [13•].

Building on the research gaps identified in the last-cited work, we have conducted an updated literature review to incorporate notable articles that have emerged in the last two years. Our aim here is to identify the new debates that have arisen regarding climate-related prudential regulation and to conduct a critical analysis of emerging perspectives on this issue and policy implications. This review will serve as a valuable resource for understanding the evolving landscape, and will contribute to the current debate on harmonized regulation in the context of the regions with the highest concentration of Global Systemically Important Banks (G-SIBs): the United States (US) and the European Union (EU).

## Climate-related prudential regulation

One of the most significant milestones in international banking regulation was the introduction of the Basel I Accord in 1988. As financial markets continued to globalize and banking practices evolved, revisions and improvements to Basel I standards became necessary.

These revisions culminated in the Basel II Accord in 2004, which not only refined international banking regulation but also set the stage for academic research and debate. The Basel II Accord organized its recommendations into three pillars: Pillar I, addressing minimum capital requirements; Pillar II, centering on banking supervision; and Pillar III, devoted to market discipline and disclosure.

The Basel III Accord of 2010 and its 2017 revision emerged as responses to the 2007–2008 financial crisis. They aimed at strengthening capital standards and enhancing banks' resilience in situations of financial stress. This crisis also revealed systemic risks due to financial contagion among banks, leading the Basel Committee to recognize as G-SIBs those banks that are 'too big to fail'. There are currently 30 G-SIBs worldwide [14].

The need to consider climate change risks in banking management was recognized by financial regulators themselves. In 2015, Mark Carney justified the need for a framework to disclose climate risks, which would assist investors in decision-making and facilitate a smooth price adjustment during the transition to a low-carbon economy, in an effort to avoid a climate 'Minsky moment' ([15]:13). Another significant milestone was the creation of the Network for Greening the Financial System (NGFS) in 2017, comprising central banks and supervisors, which presented a set of recommendations to incorporate climate risk into prudential regulation (Table 1).

The EU has moved forward in this regard with the approval of several climate-related regulations, including the Sustainable Finance Disclosure Regulation (SFDR), the EU Taxonomy for sustainable activities, Technical Standards for Sustainability Risk Disclosure, and the Corporate Sustainability Reporting Directive. Additionally, two proposed new directives (Capital Requirements Directive, CRD VI, and Capital Requirements Regulation,

CRR III) will incorporate the Basel III (2017) recommendations. These reforms are designed to enhance the risk-based capital framework by integrating environmental, social, and governance risks and standardizing supervisory tools and frameworks ([17]:2).

In the case of the US, embracing the recommendations of Basel III (2010), it enacted the Dodd–Frank Wall Street Reform (2010), which was partially replaced by the Economic Growth, Regulatory Relief, and Consumer Protection Act (2018). Additionally, the US Securities and Exchange Commission proposed changes in climate-related disclosure (2022), while the US government also proposed an amendment to the Federal Acquisition Regulation that will require public contractors to disclose their greenhouse gas emissions (2022).

Central banks and regulators are incorporating climate risks into prudential regulation [18], but a harmonized methodology for doing so is still lacking. Such delays in the US are attributed to the stands for Federal Reserve's limited authority in climate change legislation [19]. In the Eurozone, the emphasis is also on disclosure instruments [20] but the use of individualized methods creates a clear incentive to downplay risk [21]. These criticisms underline the need for harmonized regulation.

### Emerging perspectives

In this section, we will explore and categorize some emerging perspectives identified among researchers over the past two years, which represent avenues for further research on climate-related prudential regulation.

### Compensation policy

One aspect of corporate governance involves defining a compensation policy on variable remuneration and bonuses received by corporate executives for achieving company goals. The 2007–2008 financial crisis revealed

**Table 1**

#### Climate-related measures recommended by NGFS.

Measure	Basel III Pillar
Raise awareness of the relevance of climate-related risks	Pillar 2
Build capacity by convening events and working groups	Pillar 2
Develop analytical tools and methods for assessing risks	Pillar 2
Conduct and publish an assessment of these risks	Pillar 2
Analyze potential risk differentials of 'green' and 'brown' assets	Pillar 2
Issue guidance on the appropriate governance, strategy, and risk management	Pillar 2
Train supervisors to assess firms' management of these risks	Pillar 2
Set out expectations for firms' climate-related disclosures	Pillar 2
Consider integrating climate-related disclosures into Pillar 3	Pillar 3
Consider applying capital measures in Pillar 2 for noncompliant firms	Pillar 2
Consider integrating climate-related risks into Pillar 1 capital requirements	Pillar 1

Adapted from ([16]:23). Own elaboration.

shortcomings in the establishment of compensation policies [22]. Therefore, there is a need to regulate short-term incentives to improve banking governance, in line with Basel II Pillar II [23].

In practice, the dynamics of short-term financial compliance continues, which runs counter to long-term climate objectives. One of the triggers for this vicious cycle is the compensation policies for top executives that generally include variable remuneration related to the increase in shareholder value and that is partially paid with the bank's own shares or options [24–26]. This conflict of interest suggests that structural change is needed in banking, so that it focuses instead on increasing stakeholder value.

Variable remuneration as an integral part of banking risk culture is a topic that has attracted growing academic interest [27]. Two notable research works stand out: the critical analysis by Zalewska [28], who questions the banking remuneration reforms implemented since 2008, arguing that they still maintain a short-term objective; and the work of Hopt [29], who addresses the potential conflict between banking incentive regulation and labor laws. In a more recent study, Ferrarini et al. [30••] propose that reforms in variable remuneration should consider the environmental and social performance of executives, suggesting the use of a 'bonus malus'.

### Loss of biodiversity

Recent publications, including “The Changing Wealth of Nations” [31], “The Dasgupta Review” [32], and “The national strategy to develop statistics for environmental economic decisions” [33], emphasize the need to incorporate the value of nature and ecosystem services into national accounting. However, Spash and Hache [34] are concerned this approach may bypass the political debate on biodiversity loss and the structural causes of the current socioecological crisis.

The Convention on Biological Diversity has also adopted the action plan of Kunming-Montreal, which seeks to harmonize biodiversity policy in the coming years. This framework sets four goals for 2050 and intermediate targets for 2030. The link between this agreement and the 2015 Paris Agreement is important, but some have criticized the Paris Agreement for lacking intermediate targets that can involve civil society actions and government accountability [35].

Along the same lines, some researchers advocate for considering the interconnections and trade-offs between biodiversity loss and climate risks. It is argued that this is a crucial measure to avoid underestimating financial risks in banks. The inclusion of environmental risks in a broad sense is proposed [36•], and a conceptual framework for this has already been recommended [37]. In addition,

Baldwin-Cantello et al. [38•] emphasize the importance of incorporating goals related to human well-being in climate policy design.

### Financed emissions

Climate-related prudential regulation faces the challenge of how to ensure consistent carbon footprint measurement. This information is essential for disclosing climate risk, setting emission reduction targets, and determining capital provisions for climate risk management. The Greenhouse Gas Protocol (GHG Protocol) framework distinguishes three emission scopes: Scope 1 (direct), Scope 2 (indirect), and Scope 3 (value chain). In the banking context, Scope-3 emissions, linked to the loan portfolio, represent a significant portion of the carbon footprint.

Under new regulations and sustainability reporting requirements, banks must begin disclosing Scope-3 emissions. However, due to the lack of a standardized methodology, voluntary initiatives derived from the GHG Protocol are spreading. One such methodology has been developed by the Partnership for Carbon Accounting Financials [39] in line with the Science Based Targets Initiative. Another approach, which has not been extensively explored, is the Life Cycle Assessment framework and the standard ISO 14064.

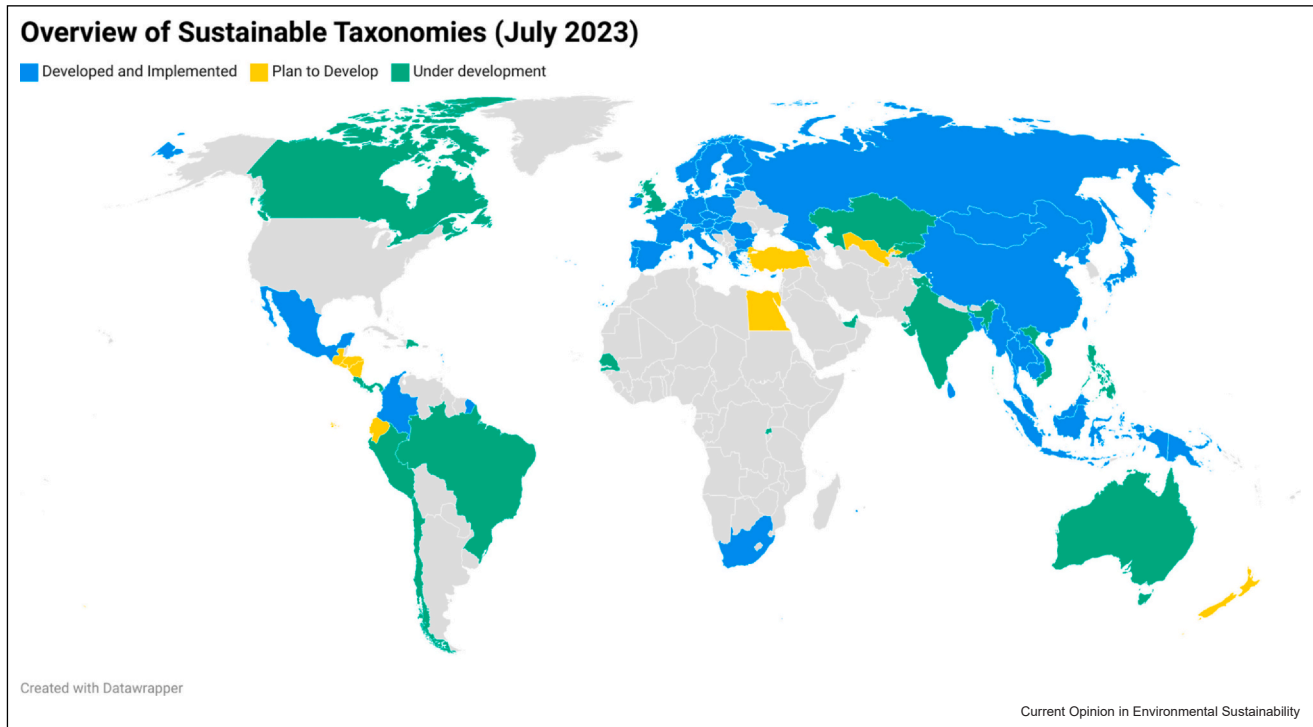
Some indicators for measuring Scope-3 emissions include absolute emissions disclosed in sustainability reports (t CO<sub>2</sub>e/year), emission intensity of productive activities (t CO<sub>2</sub>e/MWh or t CO<sub>2</sub>e/unit) using independent organization emission factors, and carbon intensity (t CO<sub>2</sub>e/€ of revenue or t CO<sub>2</sub>e/€ of assets) with sectoral emission factors. Sachs et al. ([40]:16•) argue that absolute emission reduction goals should take precedence over intensity goals and argue that avoided emissions should not be included in Scope-3 calculations.

### Systemic risk

Systemic risk refers to the probability that a crisis in a bank can spread and affect the entire financial system. Climate change risks have the potential to become systemic, threatening financial stability and the economy as a whole [41]. Therefore, early warning mechanisms to detect systemic risk are essential for effective management. Hiebert and Monin [42] highlight the need to mitigate the exposure to these risks for the whole system, suggesting the use of macroprudential tools such as systemic risk buffers or concentration exposure limits. Another macroprudential tool is the differential capital requirement, which seeks to establish an additional capital surcharge.

One of the hypotheses raised is that systemic risk is concentrated in carbon-intensive investments. For example, Bolton et al. [43•] found evidence of a discount in the

Figure 1



Overview of Sustainability Taxonomies worldwide.  
Adapted from Ref. [48]. Own elaboration.

price-to-earnings ratio in companies with higher carbon emissions, mainly in European companies, which are subject to the EU Emissions Trading System. Furthermore, a study focusing on a sample of 11 European banks found an average ratio of 'carbon assets' to capital of 95%, highlighting the magnitude of the transition risk ([44]:9). The concentration of risk in those investments underscores the importance of managing the risk involved.

Quantifying climate-related systemic risk remains a challenge. Recent studies shed light on this issue: Caporin et al. [45•] analyze the potential systemic risk that US oil and gas companies could pose in the event of a sudden transition; Gourdel and Sydow [46••] present a model to assess financial impacts from physical and transition risks and delve into the contagion mechanism and second-round effects; Yang et al. [47] focus on the spread of transition systemic risk through international financial markets, although they do not consider Scope-3 emissions.

### Sustainability taxonomies

Sustainability taxonomies have emerged as key tools in financial regulation. Their primary purpose is to direct capital flows toward sustainable investments. Initially, these taxonomies focused on green investments with minimal social safeguards, as seen in the case of the EU Taxonomy (2020). However, the scope of taxonomies

has expanded to pursue a more comprehensive agenda. A notable example is Mexico, which has developed the first Sustainability Taxonomy (2023) to address both environmental and social investments. Global progress in taxonomies is illustrated in Figure 1.

The financial impact of sustainability taxonomies has been a subject of study. Preliminary data from a survey conducted by Hoepner and Schneider [49] reveal that the alignment of economic activities with the EU Taxonomy is low. However, variations were observed among data providers, indicating potential bias in their assessments. Another study by Alessi and Battiston [50••] determined that exposure to climate risk outweighs alignment with the Taxonomy in the European space (11.7% versus 2.8%). New research could help to improve climate risk estimation based on financed emissions (Scope 3).

Table 2 summarizes all the reviewed studies and emerging research perspectives.

### Policy implications

Climate-related prudential regulation is essential to address the risks of climate change and ensure financial stability. Some of the policy implications arising from our work are summarized below:

Table 2

## Notable research on emerging perspectives.

Perspective	Author	Main Contribution
Compensation Policy	Zalewska (2022) [28]	Identifies two research gaps: the endogeneity factor between remuneration and a bank's risk profile and whether regulation fosters innovation and sustainability.
	Hopt (2022) [29]	Explores the corporate governance of banks, revealing its unique characteristics and features.
Biodiversity Loss	Ferrarini, Siri, and Zhu (2023) [30**]	Shows that the reform of directors' duties and their link to sustainability is pending.
	Spash and Hache (2022) [34]	Deconstructs the Dasgupta Review, warning about the risk of pricing nature.
	Streck (2023) [35]	Analyzes the interdependence between the Convention on Biological Diversity Action Plan and the 2015 Paris Agreement.
Financed Emissions	Kedward, Ryan-Collins, and Chenet, (2023) [36*]	Warns against addressing climate risk and biodiversity loss separately because it may lead to a misestimation of systemic financial risks.
	Baldwin-Cantello et al. (2023) [38*]	Calls for the adoption of a holistic perspective that involves local and indigenous communities in climate risk and biodiversity governance.
Systemic Risks	Sachs, Mardirossian, and Toledano (2023) [40*]	Highlights the limitations of bottom-up models, prompting a call for official pathway guidance.
Systemic Risks	Hiebert and Monin (2023) [42]	Suggests the use of macroprudential tools to address systemic climate risks.
	Bolton, Halem, and Kacperczyk (2022) [43*]	Finds empirical evidence that companies with high-carbon emissions face financial costs of carbon in the form of valuation discounts.
	Caporin, Fontini, and Panzica (2023) [45*]	Analyzes policy implications of the risk of fossil fuel dependency, given geopolitical dynamics and environmental policies.
	Gourdel and Sydow (2023) [46**]	Develops a model to assess physical and transition risks from a systemic perspective.
Sustainability Taxonomies	Yang, Caporin, and Jiménez-Martin (2023) [47]	Proposes a method to estimate systemic risk using a QVAR model, which analyzes financial markets over time and in response to different events or shocks.
	Hoepner and Schneider (2022) [49]	Makes some policy recommendations including a dynamic KPI for EU Taxonomy alignment and the revision of NACE codes.
	Alessi and Battiston (2022) [50**]	Proposes a method to estimate both alignment with the Green Taxonomy (TAC) and portfolio exposure to climate risk (TEC).

\*Special interest, \*\*Outstanding interest. Own elaboration.

- *Guided transition.* There is a need to move from self-regulation or voluntary measures in the banking sector toward harmonized prudential regulation aimed at addressing environmental risks (physical, transition, and biodiversity loss).
- *Use of macroprudential tools.* The application of macroprudential tools is key: they could include countercyclical buffers, credit limits, and differential capital requirements to standardize policies for the entire financial system.
- *Calculation of carbon footprint.* A standardized methodology for calculating a bank's carbon footprint, with a specific focus on Scope-3 emissions (financed emissions), should be developed.
- *Accelerate implementation.* The urgency of climate change must be recognized and the pace of climate-related prudential regulation must accelerate, especially in regions such as the US and the EU, given the high concentration of G-SIBs.
- *Capacity building and alignment.* It is also essential to invest in developing capabilities within the banking sector, among clients, and with suppliers to ensure alignment with climate risk management and regulatory requirements.
- *Exploration of new research avenues.* Cross-cutting research into emerging perspectives such as compensation policy, biodiversity loss, financed emissions, systemic risks, and sustainability taxonomies should be promoted.
- *Invocation of local communities.* To ensure a just transition, it is important to actively engage local communities, especially in vulnerable areas of the 'Global South,' in climate risk management, and biodiversity preservation decisions.
- *Alignment of economy with climate goals.* The economy needs to be driven to ensure that its short-term objectives are aligned with society's long-term climate goals, prioritizing investment in renewable energy, energy efficiency, and technological innovation.
- *Addressing inertia.* It is essential to promote the reduction of fossil fuel dependence and the transition to a low-carbon economy as a moral imperative for the benefit of future generations and the planet's long-term health.

## Conclusions

The critical analysis of climate-related prudential regulation in the banking sector has unveiled a rapidly

evolving landscape. The emerging perspectives in this field of research — including compensation policy, biodiversity loss, financed emissions, systemic risks, and sustainability taxonomies — provide invaluable insights into the pressing need for a harmonized and adaptive regulatory framework. The limitations and challenges of each perspective open the door to new avenues of research that can further enhance our understanding of climate-related financial risks and opportunities. As we look to the future, the imperatives of timely action and collective responsibility loom large, necessitating immediate policy adjustments and a robust research agenda to address the ongoing climate crisis.

These findings have several implications, especially in the realm of public policy. On the one hand, they introduce new dimensions into the discussion of climate-related prudential regulation for the stability of the financial system. In particular, the call to develop a standardized methodology for calculating the carbon footprint, especially in financed emissions (Scope 3), has direct implications for transparency and comparability among banks. The need to invest in capacity building within the banking sector, as well as among clients and suppliers, will be an aspect to consider in this guided transition. Finally, actively involving local communities, especially in vulnerable areas, in climate risk management, and biodiversity preservation, should be part of the agenda.

## Data Availability

No data were used for the research described in the article.

## Declaration of Competing 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.

## Acknowledgements

Research funding for this project was provided by the Universitat Jaume I (UJI-B2021-18). We sincerely thank all the anonymous reviewers for the insightful comments offered.

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