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Perspective

Pathways toward a nature-positive financial system

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SCIENCE FOR SOCIETY How can we shape a financial system that supports a just and sustainable future? The current financial system is not only linked to environmental degradation but also increasingly exposed to the risks that such degradation generates. There is an urgent need to build a financial system that is resilient to future shocks and capable of acting as a positive force in the ecological transition. While sustainable finance has gained traction in recent years, many efforts still focus narrowly on voluntary commitments and improved information flows. These approaches, though valuable, often fall short of addressing more fundamental challenges: they foster a limited sense of responsibility, neglect the systemic nature of ecological risks, and remain grounded in technocratic solutions—rarely questioning the beliefs, cultures, and institutional norms that underpin financial systems and their (in)compatibility with today's socio-ecological realities. As a result, there is growing doubt about whether current sustainability initiatives in finance can deliver the transformative change that societies and ecosystems require. This research proposes a shift in direction, it outlines key changes—so-called paradigm shifts—in how we conceptualize the financial system, aiming to realign its purpose, tools, and governance with long-term social and ecological objectives. By linking this broader vision to concrete policy measures in regulation, macro-financial supervision, and corporate governance, the work offers a roadmap for action that is both ambitious and practical. In doing so, it recenters the role of human agency and collective decision-making, reminding us that the greening of finance is not just a technical challenge but also a deeply social and political task.

SUMMARY

As human activities increasingly threaten Earth's systems, the influence of the financial system on human endeavor and nature is gaining recognition. However, discussions on sustainable finance often overlook a key insight from transformative change and complex systems research: the need to interrogate the paradigms that shape behavior. Conceptualizing finance as a complex system and drawing on the concept of "leverage points," this paper proposes three paradigm shifts that target the system's deepest level—its intent. These shifts open pathways for transformation across macro (nature-society-economy), meso (inter-institutional), and micro (intra-institutional) scales. Building on them, we identify concrete and coherent interventions targeting macro-financial supervision, regulatory frameworks, and corporate governance. Our approach contributes by (1) offering a holistic view of transformation across system scales; (2) re-centering sustainable finance on normative concerns and human agency, challenging prevailing technocratic framing; and (3) linking long-term visions with actionable interventions, connecting deep and shallow levers of change.

INTRODUCTION

Nature is undergoing unprecedented changes due to human activities driven by demographic, socio-cultural, economic, technological, and governance factors. Achieving global sustainability requires transformative change, involving *fundamental*, *system-wide shifts in views*, *structures*, and *practices*.[1]

The strategic importance of the financial system in addressing these challenges is increasingly being recognized. The financial system comprises the institutions, instruments, actors, and regulatory bodies responsible for the creation, allocation, and governance of financial resources. It includes both market participants (e.g., individual investors, banks, investment funds, and intermediaries) and public institutions

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(e.g., finance ministries, central banks, and financial supervisors). Beyond its often-assigned intermediary role, the financial system is not a neutral component of the economy. The way it manages risk, allocates capital, or influences corporate decisions gives it a powerful structuring role in the economy and therefore in the interaction between human endeavors and nature.[2]

The financial system is both associated with and exposed to nature degradation. It perpetuates nature-damaging activities through its capital allocation and incentive frameworks,[3,4] while resulting Earth-system disruptions expose it—and thus the rest of society—to (systemic) physical and transition risks.[5] In recent decades, the sustainability of the financial system has gained traction in both public and private arenas. However, many of these efforts remain confined to technical fixes and incremental adjustments, lacking integration into a systemic, long-term vision of what a truly sustainable financial system might look like, its role in addressing social-ecological challenges, and the (policy) levers necessary to realize such a transformation.

In this paper, we adopt a systems perspective and draw on the concept of leverage points to identify promising paradigm shifts and corresponding interventions capable of triggering cross-scale sustainability transformations within the financial system. Our approach offers three key contributions. First, it advances a holistic understanding of transformation processes by showing how change can unfold across the macro, meso, and micro levels of the financial system. Second, it develops a coherent and systemic perspective on financial system transformation by weaving together insights from diverse strands of the literature—(re)centering the sustainable finance debate on normative considerations and human agency, in contrast to its prevailing technocratic framing. Third, it links overarching visions with actionable points of intervention, connecting "deep" and "shallow" levers of change.

In section 2, we provide a brief review of current sustainable finance efforts, acknowledging the growing momentum to integrate social-ecological concerns into financial decision-making, while also highlighting existing gaps and limitations. In section 3, we adopt a complex systems lens to analyze the financial system, first outlining the rationale for this approach, then drawing on the concept of leverage points to conceptualize the financial system as a complex system. In section 4, we use the framework developed in section 3 as a heuristic tool to identify paradigm shifts and related strategic interventions, together outlining promising avenues for transformative change in finance. Finally, section 5 discusses tensions and synergies between interventions.

REVIEW OF CURRENT SUSTAINABLE FINANCE EFFORTS

Growing momentum

The institutional landscape of sustainable finance has evolved substantially over the past decade, gaining momentum across public and private spheres. A key inflection point came in 2015 with Mark Carney's "Tragedy of the Horizon" speech[6] and the adoption of the Paris Agreement, whose Article 2.1(c) called for aligning financial flows with low-emission, climate-resilient development.[7] These developments signaled a growing recognition of climate change as financially material and the need to catalyze global efforts to integrate sustainability into the financial system.

Since then, a wide range of "sustainable finance" initiatives have begun to emerge. The Task Force on Climate-related Financial Disclosures (TCFDs) introduced voluntary guidelines for climate risk disclosure, which served as a basis for the International Sustainability Standards Board (ISSB) in its efforts to harmonize global sustainability disclosure standards. Financial coalitions such as the Glasgow Financial Alliance for Net Zero have mobilized private institutions to set and pursue net zero targets. On the regulatory front, the European Union has spearheaded policy development with instruments such as the Sustainable Finance Disclosure Regulation (SFDR), the Corporate Sustainability Reporting Directive (CSRD), the EU Green Bond Standard, and the EU Taxonomy. Central banks and financial supervisors have also become active, notably through the Network for Greening the Financial System (NGFS), which provides guidance on integrating climate risks into supervisory frameworks, stress testing, and monetary policy operations. While climate remains the primary focus, attention is broadening to encompass wider environmental risks. The establishment of the Taskforce on Nature-related Financial Disclosures (TNFDs) and NGFS's recent stream of work on nature risk[5] signal a shift toward integrating biodiversity concerns. EU policy frameworks such as the Taxonomy and CSRD are gradually embedding these objectives, aligning with global efforts like the Kunming-Montreal Global Biodiversity Framework, whose Target 14 in turn calls for aligning financial flows with biodiversity goals.[8]

Progress, limits, and gaps

These efforts have led to notable progress in incorporating sustainability issues into financial dynamics with potential spillover effects from regional to global scales.[9] Environmental, Social, and Governance (ESG) reporting has become more widespread among companies,[10] and financial institutions are increasingly developing internal capacity to assess environmental risks.[11] Advances in data analytics are improving the measurability of environmental impacts, while financial instruments—such as green bonds, debt-for-nature swaps, and nature markets—have been developed to channel investment into green activities.[12] Increasing evidence also suggests changes in investors' perceptions regarding ecological risks. Financial markets appear to be increasingly applying a risk premium to carbon-intensive assets,[13] while recent studies suggest that a similar trend is emerging for biodiversity footprints.[14]

Progress, however, remains slow and uneven. The appraisal of environmental risks is still partial and fragmented,[15] and ecologically harmful sectors continue to attract large-scale investment.[4] While certain investment models are shifting, we are still a long way from aligning global financial flows consistently with social-ecological objectives. Although valuable, current sustainable finance efforts raise concerns about their actual transformative reach.[12,16,17]

Three interlinked critiques stand out regarding the limited transformative impact of the current sustainable finance agenda.

First, sustainable finance has relied heavily on disclosure and risk-based approaches.[18,19] These mechanisms assume that environmental risks can be optimally priced[20] and that more accurate data and better tools will "naturally" align financial flows with climate and nature preservation objectives.[18,21] However, this logic rests on assumptions of efficient markets and rational decision-making, which fail to account for the complex, uncertain, and systemic nature of ecological risks.[22] It further neglects the extent to which risk perception and financial responses are mediated by institutional logics,[23] incentive structures,[24] temporal horizons,[23] and prevailing political and economic priorities[24]—factors that cannot be addressed through improved information alone. Second, the dominant approach emphasizes voluntary standards and taxonomies designed to define and reward "green" activities while largely ignoring or failing to constrain brown or harmful investments. By focusing on incentivizing best practices rather than restricting worst practices, this framework risks reinforcing a selective, additive vision of sustainable finance—as an optional layer or niche product—rather than advancing a structural shift in financial flows.[25] Third, sustainable finance initiatives typically operate within technocratic narratives prevalent among policymakers and practitioners, which frame the greening of finance as primarily a technical issue, requiring improved data, metrics and standardization, and expertise. This framing sidelines the normative and political dimensions of finance, including its role in shaping social priorities, reproducing existing power structures, and exacerbating wealth inequality.[17]

A SYSTEMS-THINKING APPROACH TO THE FINANCIAL SYSTEM

Why use systems thinking in the sustainable transformation of finance?

Comprehending complexity

A complex system can be defined as a "*system composed of heterogeneous interacting entities characterized by varied emergent properties at the macro level, which are shaped by the structure and dynamics of these interactions*."[26] While traditional economic and financial thinking tends to depict linear relationships and equilibrium dynamics, the complex systems perspective emphasizes the non-linear, emergent, and interconnected nature of financial systems.

Systems thinking gained momentum in financial analysis following the 2008 financial crisis, which highlighted the limitations of conventional economic models and risk management tools in predicting, explaining, or preventing financial system collapse.[27] Since then, it has been increasingly used to understand phenomena such as investors' herding,[28] risk contagion in banking networks,[29] or market outcomes under heterogeneous investor profiles.[30] Building on decades of research in coupled social-ecological systems, researchers increasingly bring complex systems thinking in to better understand the systemic reach of financial risks associated with climate change[31] and the tipping points of critical ecosystems.[32]

Generating action-oriented insights

In addition to its analytical value, complex system approaches have stimulated action-oriented research for sustainability transformation. This includes levers of action, nested within complex social systems, whose activation (via public policy interventions, for example) could generate large-scale changes in the overall dynamics of systems. This research has delivered concepts, such as "leverage points,"[33–35] "tipping interventions,"[36] or "sensitive intervention points,"[37,38] some of which orient the financial system toward ecological objectives.[26,35,38,39]

Thinking deeper

Complex systems thinking sheds light on "deep leverage points" of a system.[33,34,40] Rather than focusing solely on causal mechanisms, this approach integrates the normative and institutional dimensions that shape social system dynamics—including institutional frameworks, dominant mindsets, and paradigms. Considering the deeper leverage points in finance allows us to move beyond the purely technical lens that dominates conventional sustainable finance debates. It brings into focus the cultural and institutional foundations of the financial system and questions their compatibility with broader social-ecological challenges. Instead of treating sustainable finance as a purely technical problem, this perspective frames the "greening" of the financial system as an *adaptive challenge*—one that demands new ways of thinking about both problems and solutions.[41]

Four levels of leverage in the financial system

Building on the seminal work of Meadows,[34] Abson and colleagues[33] propose a hierarchy of leverage points—defined as "places to intervene in a system"—that include *parameters*, *feedbacks*, *design*, and *intent* (Figure 1). These levels form a continuum from shallow to deep leverage points. While shallow leverage points are generally easier to influence, alone they tend to offer limited potential for transformative change. By contrast, deeper leverage points are harder to access but hold far greater capacity to drive systemic transformation.[42,43] In practice, a combination of shallow to deep leverage points is needed, with attention to how interventions at one level can reinforce or destabilize elements at another.[40]

Parameters

Parameters refer to measurable, potentially adjustable variables generally associated with mechanistic components and clearly attributable causes of system outcomes. In finance, these include elements such as interest rates, risk-return profiles of investments, asset prices, or volumes of capital flowing/locked into particular asset classes. At the parametric level, sustainable finance interventions generally aim to enhance green investments by creating targeted incentives (e.g., through voluntary standards) or promoting enabling financing instruments (e.g., green bonds and nature markets).[12] They may also seek to reduce institutional exposure to ecological risks through hedging strategies and portfolio diversification.[44]

Feedbacks

Feedback mechanisms in complex systems are processes where outputs influence inputs, shaping system behavior through cyclical interactions. Positive feedback loops correspond to self-reinforcing dynamics, while negative feedback loops are stabilizing mechanisms preventing extreme fluctuations.[36] Feedback loops can be favorable or detrimental, depending on the desired outcomes. From a greening finance

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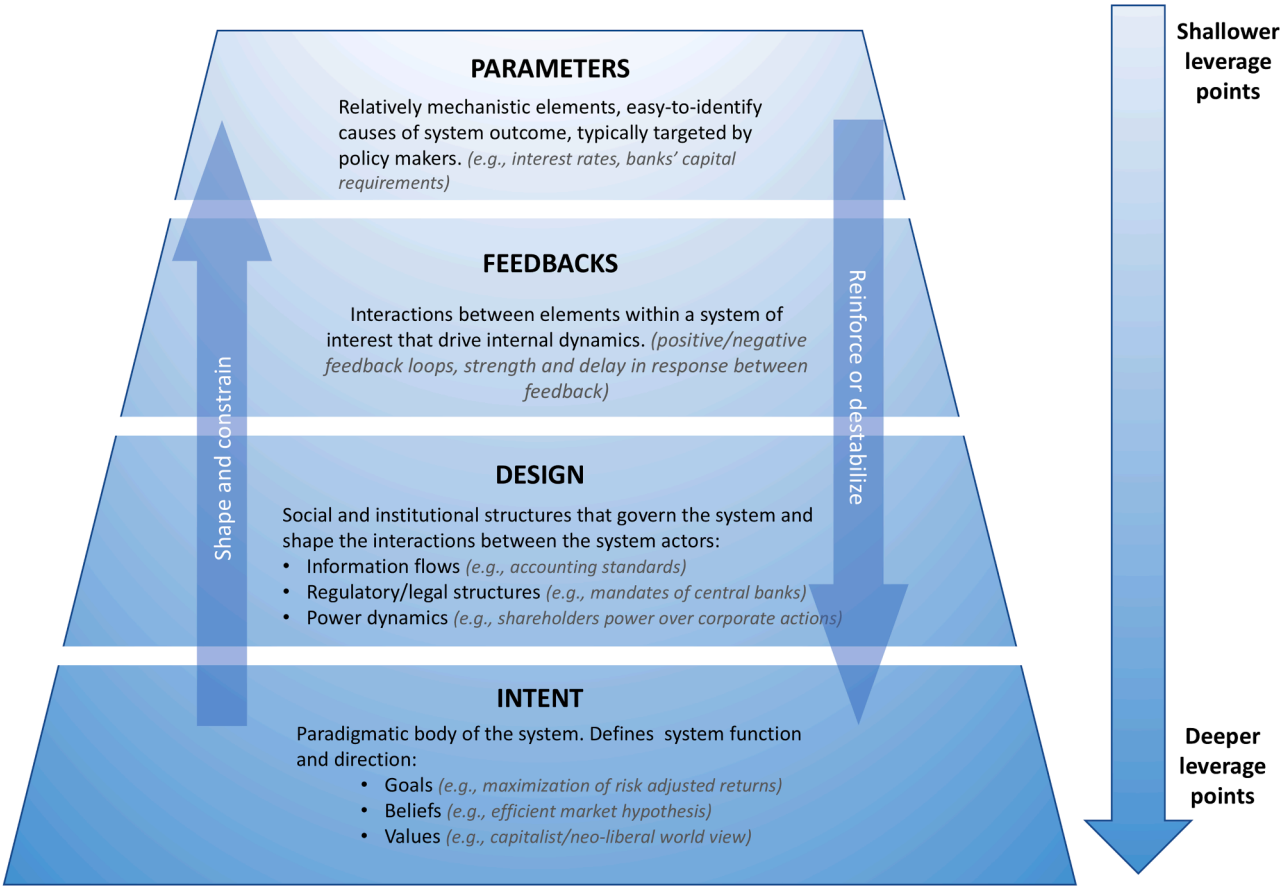

Figure 1. Four levels of leverage in the financial system

This figure conceptualizes the financial system as a complex system with four levels of leverage, which range from shallower to deeper: *parameters*, *feedbacks*, *design*, and *intent* (inspired by Abson et al.[33]). Changes at the shallower levels are typically easier to implement but alone have less transformative potential ("shallower leverage points"). Conversely, changes at deeper levels are harder to initiate but possess a relatively high transformative potential ("deep leverage points"). The system is also influenced by the interaction between these different levels of depth. While elements at deeper levels tend to shape and constrain elements at the shallower levels, elements at the shallower levels tend to reinforce or destabilize elements at the deeper levels (see dark blue arrows throughout the figure).

perspective, understanding of feedbacks enables the identification of lock-ins that lead to degradation and critical thresholds ("tipping points") that can trigger self-reinforcing positive changes (see Figure 2 for examples).

Design

The design elements of the system refer to the social and institutional structures that govern the system and shape the interactions between system elements and actors. Design elements can refer to the structure of information flows, such as the integration of ecological (and social) dimensions into financial reporting and accounting standards, which can have a decisive impact on the alignment of financial flows with ecological objectives.[45] They may also refer to formal rules that govern actors' behaviors—e.g., the extent to which central bank mandates explicitly incorporate commitments to address climate change and biosphere degradation can significantly influence the role these institutions play in driving sustainability transitions.[46] Finally, design elements may also refer to power structures that define which (groups of) actors have the most influence on the system and can potentially steer it toward their own interests or worldview. For example, the concentration of shareholders' decision-making power in corporate governance is often presented as a driver of unsustainable economic activity.[47]

Intent

Intent characteristics refer to the norms, values, and goals embodied in a system, as well as the underlying paradigms from which they originate.[33] The deepest potential for transformative change lies in shifts in intent. Intent shapes how problems are perceived, how solutions are envisioned, and the institutional logics that give meaning to actors' behavior within the system. For example, intent in current financial systems is largely shaped by neoclassical economic thought, which emphasizes individualism, profit maximization, and economic rationality.[42,48,49] The resulting dominant institutional logics—such as short-termism, the assumption of a predictable future, the risk-return trade-off, and price efficiency—are increasingly seen as incompatible with addressing ecological challenges.[23]

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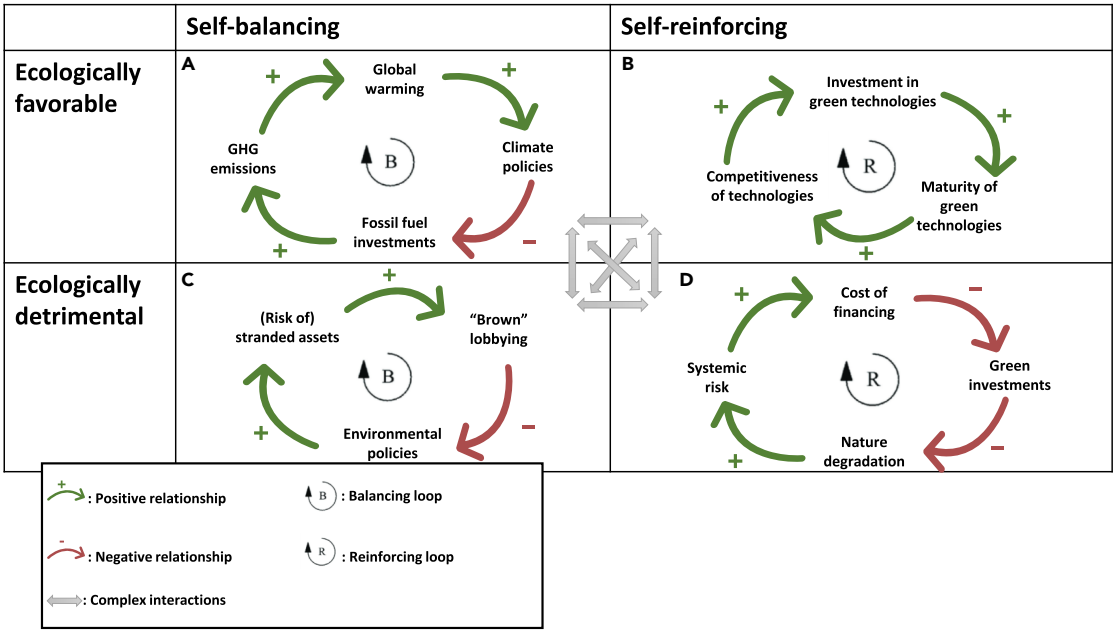

Figure 2. The financial system is governed by a complex interweaving of numerous feedback loops

(A–D) This figure provides a typology and related examples of feedback loops influencing the relationship between financial and broader social-ecological systems. Feedback loops can be self-balancing (A and C) or self-reinforcing (B and D). Their effect can be considered ecologically favorable, such as limiting investment in fossil fuels due to the strengthening of climate policy as the effects of climate change are felt (A) or self-reinforcing financial flows to green technologies due to increasing maturity and profitability (B). Feedback loops can also lead to ecologically detrimental effects. Examples include the limited deployment of environmental policies due to intensified lobbying efforts on the part of brown industries (C) or the self-reinforcing degradation of nature engendered by systemic risk and resulting limited investment in green activities (D). Taken in isolation, the explanatory power of these feedback loops is limited. The dynamics of the system depends on the complex interactions between them, as illustrated by the gray arrows in the middle of the figure.

Interactions between leverage points

The interactions between deeper system characteristics shape and constrain the types of interventions available at shallower leverage points[33] (Figure 1). System values, goals, and worldviews (intent) provide the rationale and legitimacy for regulations, norms, and power structures (design).[43,50] In turn, the capacity to intervene on given parameters and feedback elements (e.g., modifying key interest rates or adjusting banks' capital reserve requirements) can only be targeted within the framework established at the design and intent level of the system (e.g., mandate of central banks[19]).

Moreover, interventions at a shallow level may also influence deeper elements either by reinforcing or destabilizing them. Reinforcing of the current system happens, for example, when the application of a rule contributes to conveying the dominant set of beliefs and values, from design to intent. For instance, regulatory focus on risk disclosure contributes to prioritizing market discipline as the main lever for ensuring financial stability and thus reinforces the market's efficiency narrative.[21] Destabilization of the current system occurs, for example, when interventions at the parametric level contribute to strengthening the power of new minority players, thereby redefining the power dynamics within the system—from parameter to design. A case in point is the provision of public financial support for renewable energy technologies, which has helped to lower the cost of entry and operation for companies in this sector and could ultimately challenge the dominance of the fossil fuel companies.[51]

Shallow interventions alone remain limited in terms of transformative potential or may even further entrench deeper elements, thereby reinforcing the status quo and creating more resistance to deep transformation. On the other hand, interventions that focus exclusively on the deepest elements may be challenging to implement due to high exposure to system inertia. This underlines the importance of considering multi-level dynamics when assessing the transformative potential of a given intervention(s). From a transformative change perspective, the concept of leverage points gains relevance when integrated into "chains of leverage"[40] or "pathways"[52] coherently and simultaneously targeting multiple levels of depth in the system to destabilize system rigidities and progressively open the way for deep transformation.

PARADIGM SHIFTS AND LEVERS FOR TRANSFORMING THE FINANCIAL SYSTEM

Building on conceptual framing from Figure 1, we identified three scales for transformation, which emerged from a targeted literature review and expert consultations—see supplemental information for methodological details. These are (1) the *macro-scale*, which examines the financial system's embeddedness within the broader nature-society-economy nexus and its

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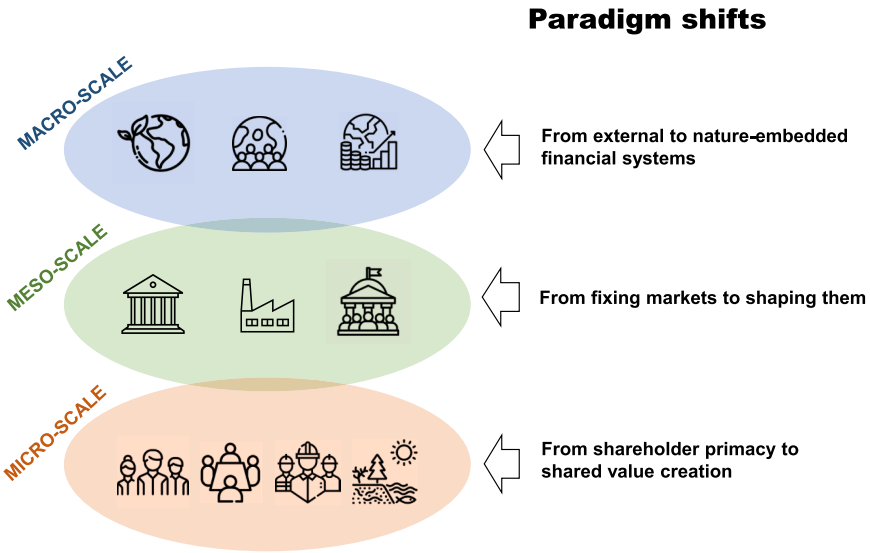

Figure 3. Three scales for transformation in the financial system and related paradigm shifts

The macro-scale examines the system's embeddedness within the nature-society-economy nexus, the meso-scale focuses on inter-institutional dynamics, and the micro-scale explores intra-institutional dynamics. For each scale, a dominant paradigm is identified, and a corresponding shift is proposed to align the financial system with sustainability objectives.

interactions with the Earth system; (2) the *meso-scale*, which focuses on inter-institutional dynamics—relationships between institutions such as banks, corporations, and government agencies operating within specific regulatory and market environments; and (3) the *micro-scale*, which explores intra-institutional dynamics—the relationships and decision-making processes of individual actors within these institutions, particularly within firms.

At each scale, we identify a dominant paradigm that hinders the integration of sustainability into the financial system's core logic. Based on these insights, we distill three paradigm shifts that provide visions for realigning finance with long-term social-ecological imperatives (Figure 3). We define paradigm shifts as fundamental transformations in these underlying mental models and system goals, occurring at the level of the system's *intent*.

For each paradigm shift, we identify corresponding interventions that target system *parameters*, *feedbacks*, and *design* elements. These interventions function as *levers of change*—entry points within the system that both stem from and contribute to broader paradigm shifts. In other words, transformations in system intent create new opportunities for action across varying levels of system depth, while the activation of strategic levers can, in turn, catalyze further shifts in intent. These interactions form mutually reinforcing pathways that drive systemic transformation (Figure 4).

Paradigm shift at the macro level

From a financial system as external...

Conventional financial theory treats finance as a neutral, objective system governed by universal laws and disconnected from its social and ecological context. This view produces an oversimplified understanding of finance-society-nature interactions,[53] reflected in sustainability efforts that rely on a narrow, investor-centric conception of risk and responsibility.[32,42,54] Thus, sustainability reporting and ESG metrics are generally embedded within corporate risk management frameworks, where social-ecological concerns are considered only insofar as they pose financial risks to investors—typically through regulatory or reputational channels.[45] This "outside-in" focus neglects the equally critical question of how financial flows themselves contribute to environmental degradation and systemic ecological risk.[5]

Moreover, financial risk assessment remains largely anchored in backward-looking models, calibrated on historical data. These models are ill-equipped to capture the unprecedented and nonlinear dynamics of ecological breakdown.[22] By fostering a misplaced sense of predictability, they overlook the radical uncertainty and irreversibility of ecological tipping points.[20]

Finally, many green financial products tend to assume that different forms of natural capital are substitutable. This logic underpins compensation mechanisms and the commodification of conservation outcomes within carbon and nature markets. However, these instruments have so far yielded mixed results, at times legitimizing trade-offs between resources and conservation efforts that are fundamentally complementary.[55]

...to an embedded financial system

Addressing ecological challenges requires reframing the financial system as embedded within a broader social-ecological landscape. Interconnected ecosystems, globalized value chains, and financial networks link distant economic agents,[56] creating complex, hard-to-trace risk transmission channels[29,57] and increasing systemic risk potential.[5] These interdependencies have two key implications. First, financial institutions are not only exposed to ecological risks—they also actively shape them. Nature-related financial risks are not merely exogenous shocks but are partly driven by the expectations and investment decisions of financial actors.[32,58] This endogeneity gives financial actors both the capacity and responsibility to steer economic activity toward ecological sustainability.[39] Second, acknowledging this responsibility means moving beyond approaches that subordinate sustainability to financial competitiveness or a narrow "business case for nature." Instead, alignment with ecological limits must become a foundational principle in capital allocation, with biosphere integrity viewed not just as risk mitigation but as a fundamental precondition for long-term economic activity and macro-financial stability.

Levers for change

Central banks and financial supervisors (CBFSs) play a critical role in a paradigm shift toward a nature-embedded financial

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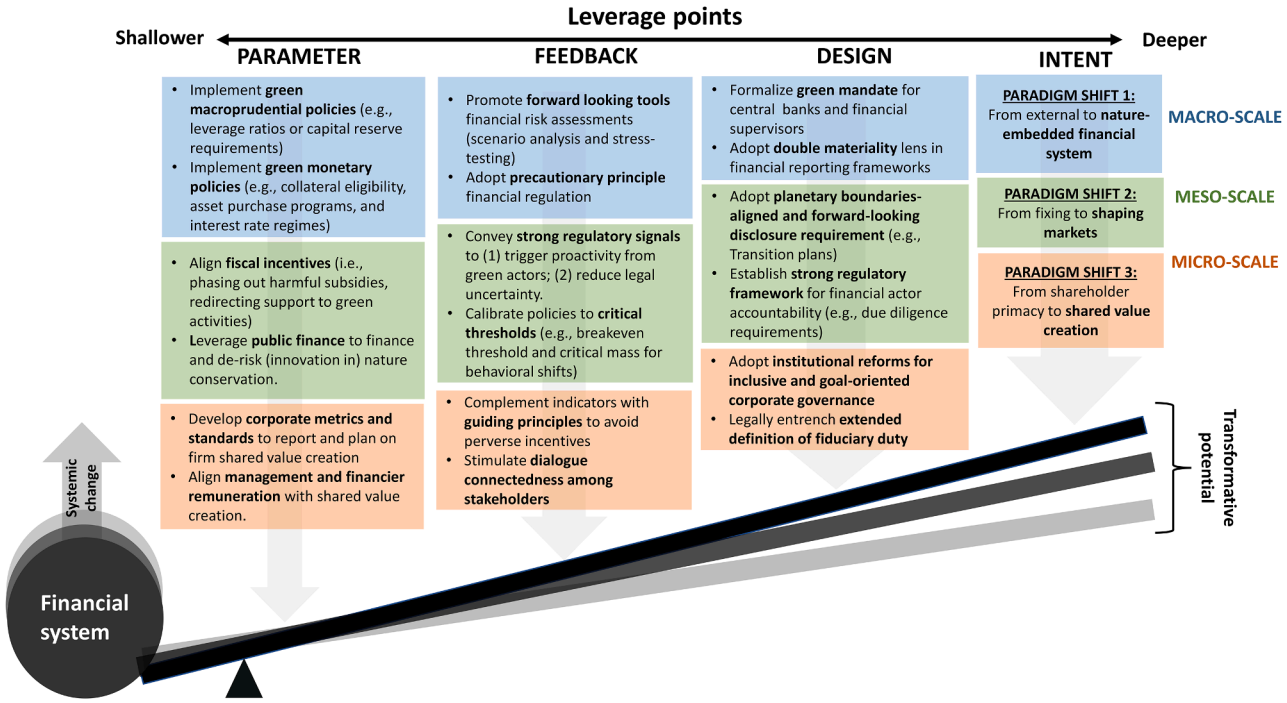

Figure 4. Multi-level leverage points for transformative change in the financial system

This figure illustrates a framework of interventions aimed at aligning the financial system with social-ecological objectives. Interventions are organized along two axes: (1) Depth of leverage, ranging from shallow (parameter adjustments) to deep (intent-level paradigm shifts), and (2) scale for transformation, spanning macro, meso, and micro levels of the financial system. The transformative potential of a set of interventions is enhanced when these interventions integrate multiple levels of depth and scale, recognizing interdependencies and fostering coherence across systemic layers.

system, as their mandates to safeguard economic stability require them to embrace the new reality of risk arising from anthropogenic disruption of the Earth system.[19]

At the *parameter* level, scholars increasingly highlight the role of green macro-prudential policies—such as adjusting leverage ratios or capital reserve requirements based on environmental criteria—for increasing financial system robustness against ecological shocks. In addition to mitigating financial stress caused by natural disasters,[59] such measures may incentivize the greening of financial institutions' portfolios, thereby contributing to reduced pressure on ecosystems.[60] Similarly, monetary policies have been identified as underutilized tools.[61] Aligning monetary policy frameworks—such as collateral eligibility, asset purchase programs, and interest rate regimes—with environmental concerns may help mitigate ecological risks by supporting green investments. At a minimum, it can prevent the continued allocation of capital toward ecologically harmful activities that current market-benchmarked monetary policy tends to perpetuate.[62]

Acknowledgment of *feedback* dynamics—and resulting nonlinearity and deep uncertainty—has led to the growing promotion and adoption of forward-looking methods, such as scenario analysis and stress testing, by financial institutions.[5] While useful, these tools remain limited in capturing the full range of possible futures[20] and still fall short of assessing the macro-financial impacts of ecosystem disruption.[63] Under radical uncertainty, scholars have highlighted the importance of a precautionary principle in financial regulation, which prioritizes minimizing catastrophic risks over optimizing theoretical outcomes.[20] Although ecological tipping points are hard to quantify, the drivers of ecological degradation are well known.[1,64] Thus, alongside deploying shock absorption mechanisms (e.g., capital buffers), a precautionary approach would proactively align financial flows to remove—or at least mitigate—activities that drive ecological harm. This underscores the need for financial supervision to be informed and supported through enhanced collaboration with experts in socio-ecological systems.

At the *design* level, meaningful intervention requires adapting financial reporting frameworks to capture both institutions' exposure and contribution to ecological degradation—embracing the principle of double materiality.[65] Deploying macro-prudential and monetary tools also requires an explicit mandate for central banks and financial supervisors (CBFSs) to address ecological risks. While such mandates exist in many emerging and developing economies, they remain nascent in most advanced economies, where the principle of market neutrality still prevails in central banking.[46] Although some progress has been made,[66] debates are dominated by potential trade-offs with price stability, compatibility with central bank independence, and the democratic legitimacy of expanding financial authority into ecological domains traditionally governed by political institutions.[67]

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Paradigm shift at the meso level

From fixing markets…

The dominant paradigm of financial system governance is grounded in the hypothesis of informational market efficiency[68] and the belief that, under conditions of perfect competition, markets are capable of allocating capital in a way that optimally supports growth and welfare.[21] In this context, regulatory interventions have primarily focused on creating conducive market conditions (enforced property rights, access to information, perfect competition, etc.) and intervening only in cases of evident market failure.[54]

Sustainable finance initiatives and regulatory measures have largely adhered to this "market-fixing" approach.[69] They have avoided imposing binding criteria on investment decisions and instead focused on improving information flows through green reporting frameworks, taxonomies, and voluntary standards.[17] The underlying assumption is that, in a conducive framework of information transparency—enabling optimal pricing—agents' rationality, combined with "market discipline," will lead participants to address environmental concerns efficiently.[21,70]

Fundamental criticisms have been leveled regarding the ability of market-centered approaches to address socio-ecological challenges.[69] First, the inability of financial markets to process information efficiently has become increasingly apparent. Recent financial crises have exposed how persistent information asymmetries fuel adverse selection and excessive risk-taking,[71] particularly amid the growing complexity of financial instruments[71] and the radical uncertainty linked to environmental risks.[22] These asymmetries go beyond unequal access to information, encompassing disparities in the capacity to interpret and act on it.[21] Differences in resources, expertise, and technological capabilities grant a small number of dominant actors disproportionate market power, undermining competitive equilibrium and challenging the assumption of optimal risk pricing.[21]

Second, financial markets display structural inertia that hinders the shifts needed to tackle social-ecological challenges.[72] This inertia is driven by capital lock-in to brown assets,[73] short-termism reinforced by institutional norms (e.g., quarterly reporting and performance-based incentives),[23] and self-referential practices—such as market benchmarking rooted in modern portfolio theory—that perpetuate existing, unsustainable capital allocations.[44]

Finally, there is a fundamental mismatch between the logic of private capital and the nature of public environmental goods. While the risk of free riding—the privatization of gains and socialization of losses—remains high, many essential climate- and nature-positive activities involve high risk, low returns, and limited standardization, which significantly hinders their integration into competitive financial markets.[12]

… to shaping markets

Markets have a critical role to play in (re)directing capital toward activities that support the social-ecological transition. However, ensuring that capital allocation meaningfully contributes to social progress requires embedding it within a broader institutional framework—one that demands far more than merely competitive and transparent markets.[69] A "market-shaping" approach to financial governance[69,74] calls for a governance approach that, alongside improving information and internalizing socio-ecological *costs*, embeds social-ecological *concerns* in financial decision-making. This approach recognizes a degree of "market plasticity"[75]—for example, in adapting to shifting environments, investor learning, and changing market actor composition—while fostering responsibility, long-termism, and public purpose. Governments thus move beyond the role of market referees to become active "market-shapers." Measures to empower market actors—such as stronger environmental disclosure—must therefore be integrated into a coherent industrial policy backed by regulation that aligns finance with sustainability and equity goals.

Levers for change

At the *parameter* level, a key area involves aligning economic incentives, particularly in the fiscal domain. Phasing out ecologically harmful subsidies and redirecting support toward green sectors would help "level the playing field" and steer private capital toward sustainable activities.[25] Researchers have also emphasized the important role of public financial institutions—particularly state investment and development banks—which can shape innovation trajectories by absorbing risk, providing "patient" capital, and coordinating stakeholders. These features enable them to support green innovation and conservation efforts typically neglected by short-term-oriented private finance.[74]

Feedback dynamics linked to investor expectations are particularly important. A clear and predictable regulatory environment—anchored in explicit goals and binding targets—can enhance the credibility of policy signals and reduce regulatory uncertainty, a commonly cited barrier to sustainable investment.[76] Moreover, public governance should account for threshold effects and nonlinear dynamics in financial systems. For instance, green subsidies and support instruments can be calibrated around break-even thresholds, beyond which private investment may become self-sustaining.[26] Similarly, identifying critical mass tipping points—where a relatively small but influential set of actors adopts sustainable practices (e.g., advanced ESG integration and fossil fuel divestment)—can generate herd effects and shift market norms.[26]

At the system *design* level, the format of information and its capacity to drive meaningful action deserve attention. Forward-looking disclosures like transition plans can promote long-term thinking and credibility,[77] while accountability for planetary boundaries can be aided by impact metrics that shift from relative—like impact per unit of output or industry benchmarks—to absolute measures.[45] However, the lack of a clear definition of "brown" activities—such as through a brown taxonomy[78]—creates information gaps that risk green investments supplementing rather than displacing harmful capital.[25] Beyond information, regulatory and legal tools are essential for steering finance. Environmental litigation already affects firm valuations,[79] and rules holding companies accountable for social-ecological damages are expanding—yet financial institutions largely remain exempt.[80] Binding environmental responsibilities, similar to anti-money laundering regimes, would strengthen accountability. The "do no harm" principle should be a regulatory baseline, but sustainability must also become a strategic concern. Large asset managers, given their systemic exposure, are well-positioned to adopt stewardship-based approaches—like beta

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activism—that address the socio-ecological roots of systemic risk, moving beyond a narrow focus on diversifying idiosyncratic risk.[44]

Paradigm shift at the micro level

Efforts to promote sustainability in finance should not rely solely on top-down regulatory pressure, which risks reinforcing resistance and avoidance strategies among economic actors. It is therefore essential that financial institutions and their clients intrinsically integrate social-ecological challenges into their strategies and objectives, rather than treating them as external compliance requirements.[39,81] While this shift can be facilitated by changes in regulatory and market structures at the meso level, transformation must also occur within organizations themselves. A micro-level perspective—focused on how financial system dynamics affect actors and their interactions within institutions, particularly firms—is essential for understanding the conditions and prospects for transformative change.

From shareholder primacy…

Contemporary corporate governance is anchored in shareholder primacy—a paradigm that regards the corporation primarily as the property of its shareholders, whose principal objective is to maximize profit and market value.[48,82] While differences in the forms and degree of shareholder primacy can be observed across countries due to variations in corporate history and legal traditions,[83] shareholders invariably maintain predominant influence over corporate strategy and goal-setting.[84] This model relies on the assumption that shareholders, as residual claimants, bear the greatest financial risk and thus have the strongest incentive to monitor managerial performance.[85]

However, shareholder primacy has come under growing scrutiny.[47,86] Critics contend that it rests on contested legal bases (see below), restricts the ability of non-financial stakeholders—such as employees and customers—to advance their legitimate interests,[87] and fosters a narrow conception of management that neglects the role of values and purpose in shaping corporate decisions.[88] Performance-wise, shareholder primacy has been linked to short-termism, managerial inefficiencies, and neglect of long-term social and environmental risks.[47,82] For instance, the legal shield of limited liability can encourage excessive risk-taking and the externalization of social and ecological costs.[89]

Jensen's "enlightened shareholder value" model argues that addressing non-financial stakeholder interests can enhance long-term returns by mitigating legal and reputational risks.[49] Some studies have indeed found positive links between firms' social-environmental performance and financial outcomes.[90] Yet, critics argue that profit and social-ecological harm are structurally intertwined and often inseparable, leading to unavoidable trade-offs.[91] Building on this critique, Hart and Zingales propose a "shareholder welfare" model that expands corporate objectives to reflect pro-social investor preferences.[92] However, pro-social shareholders' concerns and interests do not necessarily reflect those of other stakeholders or society, and, as Hart and Zingales themselves acknowledge, this can lead to situations of free riding in which shareholders pay a high price for prosocial decisions but reap only partial benefits, resulting in underinvestment in social and environmental value.

… to shared value creation

Redefining the firm's purpose beyond narrow financial value creation for shareholders involves recognizing the interests and risks associated with other stakeholders—workers, customers, suppliers, and communities.[81] Viewing the firm as a web of relationships and the managerial role as the pursuit of their balanced interests[87,93] can be institutionalized through mechanisms like stakeholder ownership[86,94] and remain compatible with profit if bounded by principles of responsible management.[95] Yet, this approach fails to represent "silent" stakeholders such as future generations or the environment.[96] Addressing this gap in the corporate social responsibility literature has advanced frameworks that embed broader ethical principles into business practice, reflecting the firm's role as a shared human enterprise, while also drawing attention to the risks of greenwashing and the marginalization of sustainability concerns.[97,98]

Levers for change

At the *parameter* level, metrics are needed to guide financial and managerial decisions both ex-ante (e.g., strategy and objective-setting) and ex-post (e.g., monitoring and accountability). Schoenmaker and Schramade propose the concept of *integrated value*—a measure of corporate value creation across financial, social, and ecological dimensions,[81] with metrics that support incentive design, for example, by linking them to remuneration schemes for financiers or corporate managers. Similar applications of ESG metrics have been associated with improvements in ESG performance.[10]

Sole reliance on metrics risks reinforcing the illusion of substitutability—for example, the notion that financial gains can offset ecological degradation—while obscuring important synergies, such as the long-term financial benefits of ecological restoration. To better account for inherent system *feedbacks*, quantitative indicators must be complemented by guiding principles, including the non-substitutability of value dimensions.[81] Such principles help ensure that corporate decision-making remains attuned to cross-domain interdependencies when governing for shared value across diverse stakeholders. The co-creation of mutually beneficial outcomes requires frequent and substantive stakeholder engagement to articulate shared normative commitments beyond shareholder-primacy logics and to cultivate the trust necessary for sustained cooperation.[99]

At the *design* level, institutional reforms could empower non-financial stakeholders and embed broader societal interests within corporate governance. Empirical studies link board diversity and ecological expertise to stronger integration of environmental concerns in firm strategy,[100] supporting proposals to include stakeholder representatives on boards. These representatives may serve permanently or through flexible, issue-specific structures.[101] Some scholars advocate recognizing the natural environment and future generations as stakeholders,[102] represented by human proxies on boards or advisory councils.[103,104] In several European jurisdictions, mission-driven company statuses embed social and environmental goals into corporate charters, sometimes supported by internal "mission committees."[105] Although currently voluntary, such models could become mandatory for large firms.[88] Legal levers may also support this shift. Shareholder primacy is not legally required: corporations are separate legal entities,

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Table 1. Tensions and corresponding cross-scale synergies

Tension	Cross-scale synergies
Ecological risk mitigation vs. core financial stability mandate	macro-meso: coordinated industrial and fiscal policies—including carbon pricing and green subsidies—can expand the pool of green assets, strengthen collateral availability, and align ecological and monetary objectives. Such policies can also mitigate potential transition risks associated with instruments like a brown-penalizing factor (BPF).
Institutional ambiguity and risk of political capture	macro-meso: align green monetary/prudential operations with pre-established policy frameworks (e.g., EU Taxonomy) to ensure complementarity and avoid mandate conflicts.
Steering systemic transformation vs. navigating wicked problems	meso-micro: corporate transition plans, structured dialog, and inclusive co-decision processes anchor firm-level strategies and actions within broader societal transformation trajectories.
Inclusivity vs. accountability in corporate governance	meso-micro: regulatory and legal instruments—such as disclosure mandates (double materiality), sustainability-linked remuneration, co-determination models, and expanded fiduciary duty—can enable governance shifts toward greater accountability and stakeholder orientation.

and limited shareholder liability challenges the notion that shareholders truly "own" the company.[47,106] Mehrotra and Morck further argue that other stakeholders—founders, employees, customers—make firm-specific investments that justify stronger claims on corporate value, challenging the idea of shareholders as residual claimants.[86] These insights echo calls from academics,[42,101,107] international institutions,[108] and civil society organizations[109] to broaden the fiduciary duties of corporate boards and asset managers to include long-term social and environmental responsibilities. Embedding this expanded interpretation into corporate law could be a powerful lever for systemic change.

TENSIONS AND SYNERGIES ACROSS SCALES

Paradigm shifts and transformative levers inevitably entail risks of unintended consequences and implementation constraints that can ultimately undermine their feasibility and effectiveness. Recognizing these tensions is essential, as it allows for the identification of critical points of attention that must be integrated into transformative strategies. At the same time, identifying such tensions also reveals opportunities for synergies across different scales of intervention, underscoring the need to view paradigm shifts as complementary and mutually reinforcing pathways that must be pursued in parallel rather than in isolation. We identify key points of tension across various levels of the system and illustrate how they can, at least partially, be addressed through cross-scale synergies (Table 1).

Ecological risk mitigation and core financial stability mandate

Potential trade-offs between mitigating ecological risks and safeguarding financial stability are frequently invoked as a key challenge for CBFS. For instance, integrating environmental factors into lending operations, asset-purchase programs, or collateral frameworks is argued to increase balance-sheet risk exposure—due to reduced diversification—and to constrain credit supply by shrinking the pool of eligible collateral, thereby potentially weakening monetary policy transmission.[110]

Yet, under certain conditions, they are also suggested to enhance rather than weaken monetary policy effectiveness. For instance, Aguila and Wullweber[61] suggest that green monetary policy measures can strengthen financial stability by mitigating inflationary pressures stemming from environmental crises. Similarly, D'Orazio and Popoyan[60] argue that a brown-penalizing factor (BPF) can reduce systemic risk by discouraging the accumulation of carbon-intensive assets while increasing capital buffers for more vulnerable exposures. Dafermos and Nikolaidi[111] find that while BPF may modestly increase transition risks by raising default probabilities and reducing output, these effects can be mitigated when such measures are combined with expansionary green fiscal policies. Likewise, green industrial policies that expand green investments can enlarge the pool of eligible green assets, improve collateral availability, and help align ecological and monetary objectives. This underscores the importance of complementarity between macro-level monetary instruments and meso-level industrial and fiscal policies.

Institutional ambiguity and the risk of political capture

A second concern regarding green mandates for CBFS relates to claims of blurring the boundary between technocratic and political responsibilities, raising fears of politicization or a weakening of central bank independence. Claiming that greening central bank activities will distort optimal pricing of assets requires an underlying assumption of market efficiency, which has limitations (see above). Conversely, maintaining monetary policies that continue to support environmentally harmful activities would contradict broader public efforts to steer markets toward sustainability.

Existing legal frameworks already provide some flexibility for central banks to support wider policy objectives. The EU treaties provide the European Central Bank (ECB) with a legal basis to contribute to the Union's economic and political goals—including sustainable development—provided that such actions do not compromise its primary mandate of price stability.

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Ensuring complementarity between the ECB's ecological actions and those of political bodies therefore requires that green measures remain consistent with its financial stability mandate while being aligned with democratically defined policy frameworks. One possible avenue is to calibrate eligibility criteria for green asset purchases in line with the EU Taxonomy. Such alignment would strengthen coherence, reduce legal uncertainty, and enable the ECB to contribute to broader sustainability objectives without overstepping its institutional remit.

Steering systemic transformation vs. navigating wicked problems

Market-shaping approaches face a fundamental tension between the need to steer systemic transformation and the inherent indeterminacy of sustainability pathways. They often encounter resistance from incumbents whose interests are threatened by structural change. Moreover, defining transformation trajectories too rigidly risks constraining adaptability and privileging certain sectors, technologies, or firms—thus reproducing the very pitfalls these approaches seek to overcome, such as rent-seeking, path dependency, and incumbent dominance.[112] Finally, implementing transformative policies involves frictions between ambitious long-term goals and short-term political cycles.

Clear, consistent, and credible regulatory signals can help reduce uncertainty and stabilize expectations among economic actors. Setting and committing to overarching targets—such as the 1.5°C climate goal and the 30x30 biodiversity target (protecting 30% of land and sea areas by 2030)—along with intermediate milestones, monitoring mechanisms, and regular review windows fosters adaptive governance capable of responding to new information and contextual change.[113] This principle can also be operationalized at the micro scale through corporate transition plans, ensuring coherence between firm-level trajectories and system-level objectives. Moreover, structured processes of dialog and co-decision—within firms and beyond—can align corporate strategies with broader societal transformation pathways, enhancing legitimacy and curbing oppositional behaviors such as lobbying, regulatory capture, or tax avoidance. Empirical evidence has notably shown that more inclusive governance arrangements—such as board independence, gender diversity, and employee representation—are associated with lower tax avoidance[114,115] and greater transparency in political activity.[116]

Inclusivity vs. accountability in corporate governance

At the micro-scale, the tension between inclusivity and managerial accountability lies at the core of contemporary debates on stakeholder-oriented governance.[117] Expanding corporate purpose to reflect social-ecological aspects appears not only as a normative imperative but also as a key condition for long-term organizational resilience.[81] Yet, such evolution may lead to a dilution of responsibilities or a weakening of performance discipline.[118] These tensions highlight the need to anchor stakeholder-related objectives within legally binding mandates, supported by transparent indicators and effective regulatory oversight.

At the meso level, several institutional and regulatory levers can foster such alignment. Adapting reporting standards to require firms—including financial institutions—to disclose both their ecological impacts and exposure to ecological risks, in line with the principle of double materiality, would strengthen internal capacities to identify, assess, and communicate these issues. Complementary public standards on ecological performance metrics—particularly in critical sectors such as energy and agriculture—would help define credible and comparable indicators to be integrated into managerial incentive schemes, ensuring that remuneration structures are aligned with social-ecological objectives. Likewise, regulatory frameworks can promote more inclusive governance structures, drawing inspiration from the German co-determination model. Finally, explicitly enshrining an expanded conception of fiduciary duty—one that incorporates social-ecological considerations—in corporate law could provide a structuring lever.

Conclusion

Human-induced disruptions to the biosphere pose unprecedented risks and challenges to economies and societies, demanding transformative change to achieve global sustainability. The financial system is both implicated in—and increasingly exposed to—biosphere degradation. It requires urgent transformation to enhance its resilience to future shocks and to serve as a positive force in the social-ecological transition. Scholarly attention to the financial system's role in addressing social-ecological challenges has grown across an expanding body of literature. While offering valuable insights and proposals, this research remains fragmented—rooted in diverse disciplinary traditions and addressing the issue from various angles, including financial risk, regulatory frameworks, and corporate finance. This fragmentation complicates the development of a coherent and integrative vision for sustainable finance, as well as the identification of concrete pathways for implementation.

This paper addresses this gap by adopting a systems-thinking perspective and integrating insights from across the literature. It proposes three paradigm shifts to support financial system transformation: from an external to a nature-embedded financial system, from market-fixing to market-shaping, and from shareholder primacy to shared value creation. Building on these shifts, the paper identifies corresponding interventions—levers of change—across multiple levels of the financial system, laying the groundwork for a transformative approach to sustainable finance. While not claiming to exhaustively identify all relevant paradigms, this paper offers a novel systemic framework that links long-term visions with actionable short-term steps. Its attention to actors at different scales (macro, meso, and micro) aims to open new avenues for reflection and debate, particularly by re-emphasizing the role of human agency and normative commitments in a policy space still dominated by technocratic approaches to the "greening" of finance.

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AUTHOR CONTRIBUTIONS

P.D. wrote the original draft of the manuscript. The study was conceptualized by P.D., F.A., and J.N. Supervision was provided by F.A. and J.N. All authors—P.D., F.A., J.N., and D.S.—contributed to the review and editing of the manuscript.

DECLARATION OF INTERESTS

The authors declare no competing interests.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT to assist with language refinement and proofreading. All content was subsequently reviewed and edited by the authors, who take full responsibility for the final version of the manuscript.

SUPPLEMENTAL INFORMATION

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