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Perspective

# The Anthropocene reality of financial risk

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## SUMMARY

**Globally, financial services are well positioned to contribute to the transformation needed for sustainable futures and will be critical for supporting corporate activities that regenerate and promote biosphere resilience as a key strategy to confront the new risk landscape of the Anthropocene. While current financial risk frameworks focus primarily on financial materiality and risks to the financial sector, failure to account for investment externalities will aggravate climate and other environmental change and set current sustainable finance initiatives off course. This article unpacks the cognitive disconnect in financial risk frameworks between environmental and financial risk. Through analysis of environmental, social, and governance ratings and estimates of global green investments, we exemplify how the cognitive disconnect around risk plays out in practice. We discuss what this means for the ability of society at large, and finance in particular, to deliver on sustainability ambitions and global goals.**

## INTRODUCTION

While it is notoriously difficult to calculate the exact size of the global financial services sector, there is no doubt it is a key factor affecting both social and environmental development in the Anthropocene era.[1–3] As such, it has power to also contribute to the rapid transformation needed for the world to deliver on the targets of the Paris Agreement and the Sustainable Development Goals. Ultimately, the finance sector will, through its influence through both ownership and capital allocation, become critical in regenerating the resilience of the biosphere as a key strategy to confront the new risk landscape of the Anthropocene.[4]

Interest in sustainable finance has grown significantly in the last decade. The Principles for Responsible Investment (PRI) launched in 2006 now has over 3,000 signatories, with more than $100 trillion in assets between them.[5] Rapid increase in various green investment instruments, like green bonds or sustainability-linked loans, indicates growth in sustainable finance,[6] and mutual funds and exchange-traded funds designated as sustainable by Morningstar attracted $46 billion in inflow in the first quarter of 2020.[7] Global issuance of green bonds recently surpassed $250 billion, representing ca. 3.5% of total global bond issuance ($7.15 trillion).[8] Together, these facts illustrate that climate and environmental change are a concern throughout large corporate and financial communities. Yet, the multiple, often complex, mechanisms by which environmental change unfolds and is aggravated by investments are not equally recognized. Climate, biodiversity loss, water, and land-use change are not isolated phenomena, but directly interconnected and mutually reinforcing processes.[9] For example, deforestation to produce oilseed in one region leads to regional drought affecting the oilseed production itself, but also affecting geographically distant sectors, such as aquaculture reliant on oilseed for feed input.

Failure to see these connections matters. If they are not recognized in risk assessment tools, strategies, and solutions used to address the problem, these will deliver only partial results, despite significant human and financial capital invested. In addition, most detrimental risks of climate change on portfolios may very well arise from second-order effects, rather than direct ones, making this a serious source of financial risk to investors.[10] Avoiding a "hothouse Earth" scenario of escalated warming[11] requires the financial sector to account for the wider set of biophysical processes, beyond greenhouse gases (GHGs), that influence the functioning and resilience of our living planet and human life as part of it.

This article contrasts widespread conceptions of climate-related financial risks (such as those of the Taskforce on Climate-Related Financial Disclosures [TCFD]) with insights from Earth system science, to highlight the disconnect between environmental and financial risk in prominent financial risk frameworks. We show the necessity of a broader conceptualization of climate and environmental risk to avoid devastating impacts on the economy, society, and biosphere as a whole. We then use environmental, social, and governance (ESG) investments as a means to exemplify how the cognitive disconnect plays out in practice and its implications for the ability for society at large, and finance in particular, to deliver on sustainability ambitions and global goals.

## EARTH SYSTEM DYNAMICS AND FINANCIAL RISK

To date, the financial sector focus on climate has primarily centered on reporting and monitoring of GHG emissions and capture, by companies and investors alike (see, e.g., the PRI's *Climate Action 100+*). However, a broadened scope is needed to consider other key parts of the Earth system, including their complex interactions and non-linear properties.

Multiple sources of scientific evidence show that a stable climate is determined not just by GHG emissions, but by a complex set of interactions between human activities and large-scale biological, geological, and physical processes related to, e.g., forest and land-use dynamics, global hydrological flows, and radiative forcing.[9,11–14]

For example, until recently the oceans absorbed about 30% of carbon emissions[15] and land-based ecosystems like forests, wetlands, and grasslands, which draw down carbon dioxide through growth, all in all sequestered close to 30% of anthropogenic $CO_2$ emissions.[16] Land-use dynamics, and investment decisions that affect them, therefore play a key role in climate change. They shape vegetation types and storage of carbon in aboveground biomass, but also in the soil, which represents about 70% of the terrestrial carbon (1,500–2,400 Gt C).[17] Soil carbon (including permafrost) is about 4.5 times larger than the atmospheric pool and about 5 times larger than the carbon found in living plants and animals.[18] Oceans represent an even larger carbon pool, at about 38,000 Gt of carbon.[19] Terrestrial and marine biomes represent important carbon sinks. Keeping and enhancing these sinks are essential for stabilizing the climate system.

Land use also affects moisture recycling and rainfall patterns across local, regional, and global scales.[20] Nearly a fifth of annual average precipitation falling on land is from vegetation-regulated moisture recycling, with several places receiving nearly half their precipitation through this ecosystem service.[21] Such water-land connections are critical for semi-arid regions reliant on rain for agricultural production and water supply.[20] They also represent critical feedbacks for climate stabilization because land use affects moisture recycling and precipitation, which in turn affects land productivity and carbon sequestration capacity.[20]

The interactions between the living biosphere and the broader Earth system and the way human actions shape this interplay are fundamental to tackling climate change and regenerating biosphere resilience.[4] The examples highlighted here represent only a fraction of the dense network of interactions between critical processes of the biosphere and the Earth system for which evidence exists.[9,11,22,23] Yet, they show that climate stability hinges not just on the atmosphere. To date, however, such critical interactions are not generally addressed or acknowledged by the financial sector or sustainable finance scholars.[24–26]

### Threshold dynamics and tipping cascades

Threshold dynamics have also become a critical dimension of climate change research.[13] These thresholds are associated with abrupt change in the internal dynamics of specific biophysical subregions of the planet, such as melting of the Greenland and Antarctic ice sheets and Arctic sea ice, changes in ocean and atmospheric circulation, and loss or alteration of large ecological regions such as the Amazon.[13] Combining current observations of rapid change in these regions[27–30] with past records and climate models shows that these regions can flip to new states abruptly and with little immediate warning.[31]

The way in which the internal dynamics of specific regions (such as the Amazon) can affect other regions and the global climate has been described as "tipping cascades."[11,13] Such cascades are a manifestation of emergent risks long recognized by systems scientists.[32,33] They represent systemic risks, i.e., having not just independent, but interdependent and cascading failures (or domino effects, as referred to in economics) in a network[34] (see Martínez-Jaramillo et al.[35] and Billio et al.[36] for reviews of the concept in financial economics). An example is when extreme weather interacts with the food system to create synchronous challenges among disconnected areas that rapidly cascade across countries and regions.[37,38]

Complex dynamics, such as threshold effects (tipping points) and strong interactions resulting in cascading effects, are all known drivers of systemic failure in any complex system.[34] Yet state-of-the-art risk analyses still do not adequately account for them.[34,39] Even financial risk frameworks explicitly aimed at incorporating climate systemic risk (e.g., Aglietta and Espagne)[40] fail to recognize that propagation mechanisms can also be linked to interconnections between Earth system processes.[9,41] They consider merely social and economic elements.

Many disasters have happened because of a failure to imagine that they were possible and therefore to build insurance to be prepared.[42] A new approach to dealing with the climate issue and an upgraded conceptualization of risk in the financial sector is therefore urgently needed.

## THE NEED TO COGNITIVELY CLOSE THE RISK LOOP

Risk frameworks used in sustainable finance contexts generally consider two overarching types of risk: (1) those arising from changes in social preferences, regulations, or other socially constructed sanctions and (2) those arising from physical risks to economic activities (e.g., TCFD, Sustainability Accounting Standards Board).[43,44] The TCFD (named after the industry-led task force assembled to develop it) is currently the most widespread and adopted risk framework for reporting corporate climate-related risk and incorporating it into financial decision-making in Europe and parts of North America, and multiple authorities are considering making these disclosures mandatory.[45–47] The emerging Taskforce on Nature-Related Financial Disclosures is modeled on the TCFD and aims to help financial institutions shift finance from destructive activities and toward nature-based solutions.

While corporate and financial communities increasingly acknowledge the importance of multiple environmental risk factors, such as water and biodiversity, in addition to carbon emissions (e.g., Global Reporting Initiative [GRI], Sustainability Accounting Standards Board [SASB], Carbon Disclosure Project [CDP], Science-Based Targets Initiative [SBTi]), most (excluding the GRI) continue to base assessments solely on financial materiality and conceptualize, and therefore measure, risk solely as risks *to* the financial sector from climate change via some intermediary source (e.g., water scarcity or crop failure). As such, these frameworks do not acknowledge that investee companies often directly contribute to exacerbating the physical risks they are trying to assess and manage, thus contributing to the risk of systemic failure (e.g., Helbing).[34]

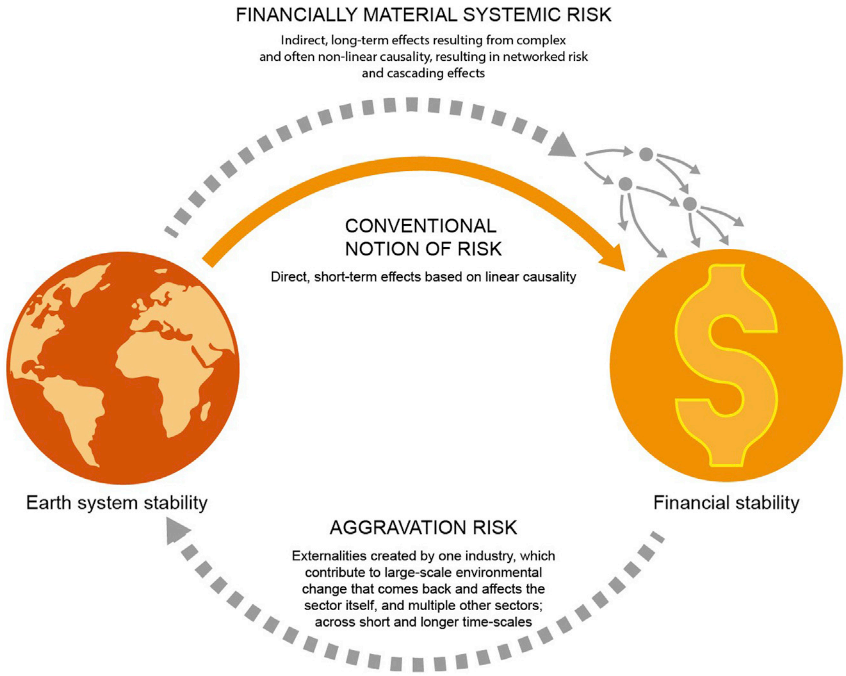


**Figure 1. Closing the cognitive "risk loop" for sustainable investments**

Solid arrow represents the perception of risk by most conventional financial sector risk frameworks. Bottom dashed arrow indicates the aggravation risk that results from negative externalities caused by investments, which in turn translates into financially material systemic risks (at different timescales). These systemic risks are characterized by complex causality where impacts of one economic sector affect itself and/or other sectors, through both direct and indirect causal mechanisms.

To clarify the link between Earth system dynamics, biosphere resilience, and systemic risk we can use companies operating in the Brazilian beef and soy industry. Deforestation linked to the agricultural sector in Brazil could certainly be a reputational or a litigation risk if policies and laws were enforced.[48] But it is not yet a direct short-term physical threat to either soy or beef industries as a whole, because impacts of deforestation on the agricultural sector are delayed and characterized by feedback, where reduction of the forested area undermines the capacity of the remaining forest to generate its own rain.[28] However, it is highly likely that this externality will diminish the long-term capacity to conduct rain-fed agriculture in the region itself.[49,50] Furthermore, through the global interconnections between Earth system processes,[9] it will affect rainfall and climatic conditions in multiple other regions,[51,52] thus increasing the potential that investments in agricultural commodities far removed from the Amazon are also negatively affected.

These well-documented effects of Amazonian deforestation illustrate how mismanagement by an industry of one or several natural capitals not considered material for their own operations results in contributing to large-scale environmental change that will come back and affect the sector itself, as well as multiple others, across short and longer timescales. It thus shows how externalities translate into financially material risk. We refer to this as aggravation risk (Figure 1).

Sustainability risks as currently included in, e.g., TCFD, arguably do capture some notion of negative impacts because companies without any environmental externalities would arguably not worry about regulation or reputational risk related to these. Yet capturing environmental risk in this way does not allow for a nuanced conception or assessment of the nature and magnitude of the risk, also referred to as absolute sustainability (*sensu* Bjørn et al.).[53] Furthermore, it means that where a company sits in a global supply chain can end up becoming a stronger determinant of risk than the environmental externality itself. Companies with consumer-facing brands are generally more vulnerable to reputational risk, even though their environmental impact on Earth system functioning may be seen as less severe (e.g., an isolated pollution event). In contrast, a company with significant environmental (or social) impact (such as contribution to deforestation in a tipping element like the Amazon) may not see reputational and litigation risk as high despite their severe negative externalities, simply because they do not have a consumer-facing brand and are operating in a weak institutional environment (like Brazil) where the likelihood of being penalized for illegal deforestation is minimal.

In summary, our principal argument is that if companies and investors rely entirely on regulation and reputation to determine risk, they essentially outsource the responsibility for risk assessment and in doing so miss an opportunity to take control over a crucial strategy to mitigate systemic risk. If, instead, they were to acknowledge the link between the externalities of economic activities and the creation of systemic risk through near-term and long-term cascading effects (see, e.g., Rocha et al. and Cottrell et al.),[37,38] investors could work individually or collectively to reduce negative externalities so as to minimize the magnitude of the financially material risk they invariably present (Figure 1). Phrased more succinctly, cognitively closing the risk loop is a means to mitigate and reduce future financially material and possibly systemic risk.

Antoncic[54] outlines the exceptional development in risk definitions in the financial sector over the past 3 decades. A similar trend is supported by the shifting focus of risk discussions in the annual reports by the World Economic Forum.[55] This rapid development in the definition of financially relevant risks shows that a shift to also consider *aggravation risk* is possible.

## The end of hedging?

The preceding discussion is directly relevant to financial risk management. Managing investment risk hinges on diversification. Conventional portfolio risk management is limited to diversifying idiosyncratic risk (managing alpha) by selecting securities across different financial assets. It further assumes that this diversification has no influence on market-wide issues that could affect multiple asset classes (beta). Hawley and Lukomnik[56] argue that this assumption—that systemic risks affect

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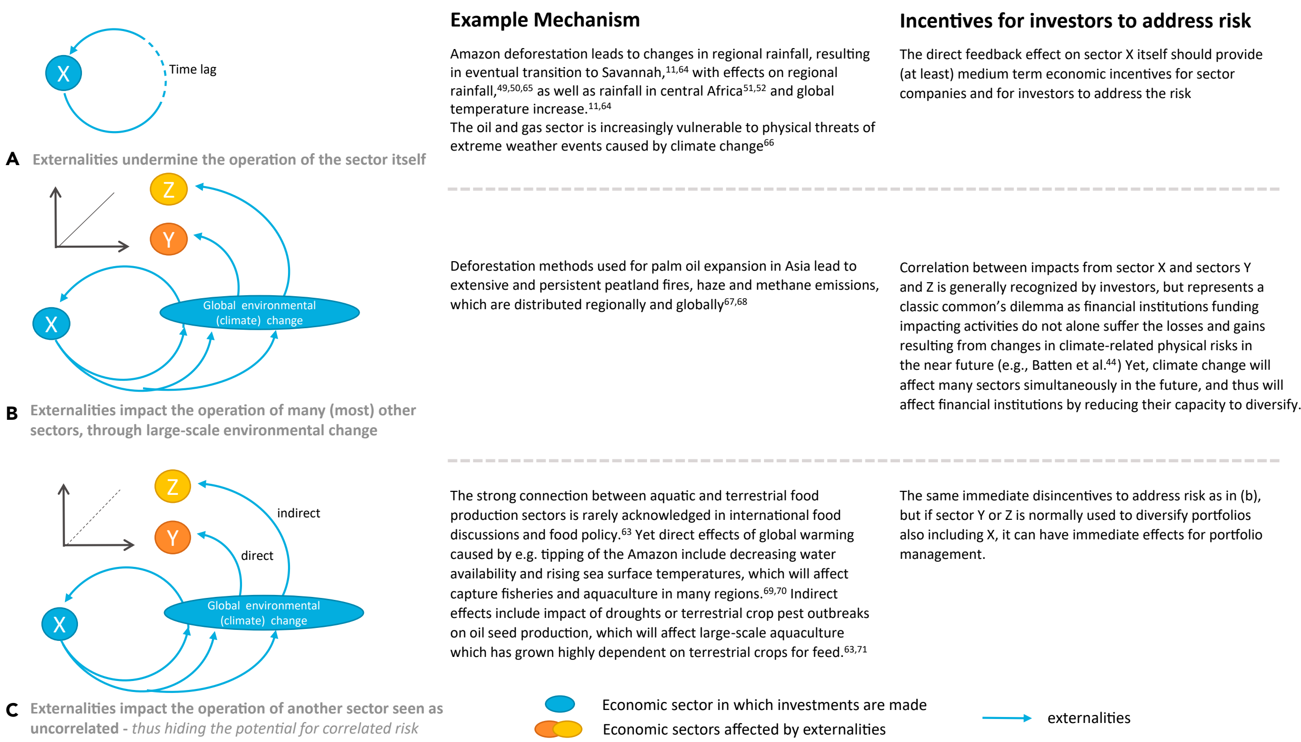


**Figure 2. A typology of how externalities lead to financial risk**

(A–C) Three distinct types of externality have an impact on financial risk. (A) Externalities undermine the operation of the sector itself; (B) externalities impact the operation of many (most) other sectors, through large-scale environmental change; and (C) externalities impact the operation of another sector seen as uncorrelated, thus hiding the potential for correlated risk. Each type is underpinned by a generalizable causal chain by which externalities on multiple Earth system processes affect financial risk. References for these include Yang et al.[64], Swann et al.[65], Cruz and Krausmann[66], Reijnders and Huijbregts[67], Meijide et al.[68], Barange et al.[69], Cheung et al.[70], and Cottrell et al.[71] The nature of the causal mechanism of impact on financial risk also results in a particular set of incentives (or disincentives) for the financial sector to address the risk. The stylized graph included in (B) and (C) indicates whether causality is likely to be directly observable (solid line), or where causality is indirect (dashed line). Direct emissions of $CO_2$ (i.e., scope 1) from industry activities are already well known and addressed (see, e.g., SBTi [https://sciencebasedtargets.org/] and CDP [https://www.cdp.net/en]) and not included in this figure.

investments, but are not affected by these same investments—is the single biggest theoretical failing of modern portfolio theory. They thus support the core argument for considering aggravation risk.

For large institutional investors and so-called "universal owners," with highly diversified and long-term portfolios representative of entire capital markets, climate change has already been recognized as a key driver of future value and not an externality (see, e.g., the Japanese Government Pension Investment Fund). Coalitions have therefore emerged to rally this highly concentrated segment of the financial sector into action (see, e.g., Climate 100+, with over 500 investors as signatories and more than US$47 trillion in assets under management), yet to date these remain focused only on shifting away from fossil fuels and do not consider the interconnected dynamics between economic activity, Earth system dynamics, and biosphere resilience as outlined above.

The general focus on short-term maximization by corporate boards and asset managers would speak against the possibility of even considering these complex, indirect, and sometimes longer-term feedbacks. However, the effects may be closer than envisioned. The number of annual catastrophic events has risen sharply in recent years. Using data from Munich Re, Antoncic[54] shows that this correlates with a 7-fold increase in claimed losses (from $50 billion in 1980 to $350 billion in 2017). As climate change-related risks, such as storms, fires, and sea-level rise, all mount and occur simultaneously, the sheer volume of material assets affected and the multiple types of liabilities incurred threaten to trigger a crisis of insurability.[44,57,58]

The 2008 financial crisis was triggered, in part, by extreme interconnectivity among financial institutions, making diversification impossible.[59–61] As shown above, key processes that underpin the functioning of the Earth system and stabilize the climate are similarly interconnected,[9] and crossing increasingly well-known tipping points risks causing cascading impacts across regions,[13,37] albeit at longer time-scales.

Figure 2 outlines a typology for how externalities and Earth system connectivity combined lead to financial risk, and begins to identify how this translates into both possibilities and barriers for incentivizing action among investors. Figure 2A represents the situation where externalities undermine the operation of the sector itself (albeit with some time lag), exemplified in previous sections through the Amazonian agricultural sector. Figure 2B expands this to include instances where externalities affect the operation of many (or even most) other sectors, through large-scale environmental change. Such situations represent a classic common's dilemma (*sensu* Ostrom)[62] as financial institutions funding impacting activities do not alone suffer the losses and gains resulting from climate-related physical risks in the near future (e.g., Batten et al.).[44] However, climate change will affect many sectors simultaneously in the future. As such it will affect financial institutions by reducing their capacity to diversify, making the issue highly salient for them to act on. Figure 2C is similar to 2B but illustrates situations where externalities are not limited to direct effects, but affect the operation of sectors normally viewed as uncorrelated. Soy and seafood production are one example of such indirect effects. Previously uncorrelated, aquaculture in Norway or China is now highly dependent on oilseed for feed[63] and therefore directly affected by droughts or crop pest outbreaks in, e.g., South or North America.

Figures 2B and 2C thus highlight how Earth system connectivity, combined with globalized value chains connecting asset classes across geographies, translates into a diminishing capacity for portfolio diversification (Batten et al.,[44] cf. Cottrell et al.[38] for examples of cascading effects from food system shocks). These types of systemic effects can be hard to predict with precision, and tend to be actively ignored as the risk cannot be quantified or easily modeled.[72] Furthermore, most financial risk assessment still relies on historical data,[44,73] and would underestimate or completely miss the potential for thresholds and cascading effects not previously experienced. While the exact effects of crossing tipping points in the Earth system may still be "unknown unknowns" (see Faulkner et al.[74] for review of deep uncertainty), the existence of planetary-scale thresholds is becoming an increasingly well-established part of the risk landscape (a known unknown)[74] that deserves attention and deliberate action.

### Barriers to delivering on sustainability ambitions

2ESG frameworks are a good example of how the cognitive disconnect plays out in practice. ESG refers to a collection of often divergent approaches to using non-financial data for socially responsible investment strategies. ESG grew out of a socially responsible investment movement emerging as early as the 1960s, and early versions were motivated by a belief in sustainable development, adopted a systems view, and focused on capturing absolute assessments of corporate externalities.[75] However, as the interest in ESG issues rose in the wake of the 2004 UN Global Compact report,[76] the financial materiality-driven rationale was favored by the major rating providers (such as MSCI). According to Eccles et al.,[75] this was because such an approach was easier to scale, was most closely aligned with investor needs for financially focused assessments, and also arguably did not challenge investors to reflect on more complex externalities.

This way of conceptualizing ESG issues now dominates sustainability approaches adopted by prominent norm-setting actors such as the SASB, the TCFD, and the limited set of ESG providers that hold the majority of market shares in the highly concentrated market segment of ESG rating services.[77] Nonetheless, the rhetoric around what ESG integration in investments can do for sustainability remains surprisingly unchanged. Countless blogs and articles on sustainability geared toward financial audiences reinforce the idea of ESG scores as a means to shift sustainable investing from a "niche" practice requiring specialized knowledge to one that is more accessible to a far wider range of prospective investors.

A prominent example is the Morningstar Sustainability Rating for Funds, launched in 2016 as a tool to rank both mutual and exchange traded funds on the basis of their sustainability scores. It uses 1–5 "globes" to visualize ratings, where globe ratings are based on the simple logic that the total sustainability of a fund's portfolio is the asset-weighted sum of the sustainability rating of its holdings. While the sustainability score for each individual holding is based on financial materiality (as it is based on the Sustainalytics ESG Risk Rating), the tool was ostensibly developed to help investors compare funds based on sustainability, not just financial performance. Consequently, the globe rating tool is presented by Morningstar as a means to help investors put their money where their values are and provide a "reliable, objective way to evaluate how investments are meeting environment, social, and governance challenges."[78]

Analysis shows that in the United States alone, the market-wide demand for funds varies as a function of their sustainability ratings, where 5 globe Morningstar funds get a considerable inflow of capital, while 1 globe funds receive less.[79] In the year following the launch of the Morningstar sustainability rating tool, funds scoring high on sustainability (4–5 globes) received a total net inflow of more than $24 billion, while those ranking low lost $12 billion in investments.[79] This shows the power of ESG and rating tools to move markets and is precisely the ambition of the financial industry.

The irony is that current ESG ratings are based on a risk perception that does not account for externalities, and therefore is unlikely to address the root causes undermining sustainability. A comparison of deforestation risk and environmental ESG scores emphasizes this point. Correlation between the environmental ESG score of one prominent ESG provider (Refinitiv Eikon) and deforestation risk scores for 143 companies covered by the annual Forest 500 review shows that environmental ESG scores currently do not capture well the assessed risk of company operations and trade (Figure 3 and supplemental experimental procedures). In fact, companies with documented poor engagement with deforestation risk-reducing measures receive some of the highest environmental ESG scores.

Proliferation of ESG metrics and the lack of coherent and agreed-upon standards for rating a company's ESG performance is already a problem well recognized by sustainable finance scholars and practitioners.[80–82] This divergence in ESG ratings has spurred debates about what reliably constitutes a sustainable investee, as it prevents comparison of the performance of ESG investments.[81–83]

More importantly for our discussion, however, is the lack of consideration of externalities in ESG measures across the board. This precludes assessments of actual investor contribution to lessening environmental degradation, and the direct and systemic risks associated with it, and it runs an acute risk of developing sustainability strategies that are off the mark (Figures 3B and 3A). We return to the implications of this in the last section.

## SUSTAINABLE FINANCE 2021: REARRANGING GREEN DECK CHAIRS?

Achieving a sustainable future leaves no choice but to avoid a transgression of planetary boundaries and tipping points in

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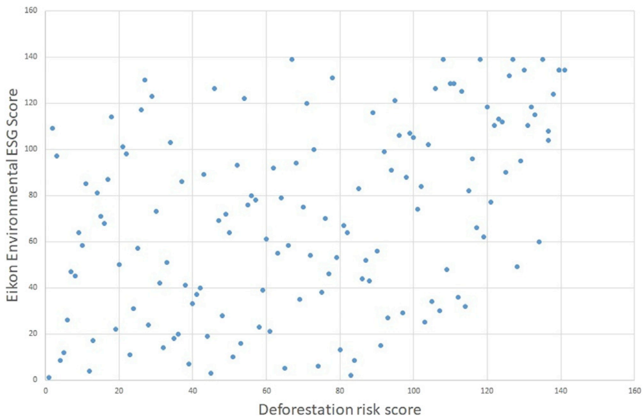


**Figure 3. Comparison of deforestation risk and environmental ESG scores**

Spearman rank correlation (0.42), $p < 0.05$. Data are from Forest 500 and Refinitiv Eikon; see the supplemental information for details of the analysis. The higher the deforestation risk scores the better a company is deemed by Forest 500 to address deforestation issues in their supply chains.

key Earth system processes.[11,13] In systems science it is well established that thresholds in systems are easily overshot when feedback has long delays, leading to collapse.[33,34,84] Since shortening the time lag of how the Earth system operates is not possible, two things will be key to achieve a financial system that fundamentally promotes long-term sustainability: (1) incorporating the necessary information feedback and (2) developing structures by which this information is taken into account and acted upon. The two cannot be treated in isolation.

Incorporating information (i.e., impact metrics) that can assess the degree to which investments move us toward or away from planetary boundaries and tipping points is paramount. However, this information cannot be acted upon unless the underlying framework for assessing risk is adjusted to allow this information to be processed, i.e., cognitively closing the risk loop. Doing the latter would also open up for a re-evaluation of what green, or environmentally sustainable, investments are and should be. In the next section we take a first step toward opening such a re-evaluative discussion by examining what green investments are today, and what this means for the ability of finance to deliver on sustainability ambitions and global goals.

Figure 4 details the most widespread types of green investment instruments across the broad categories of debt and equity for which summary statistics can be calculated for 2019 (see supplemental experimental procedures for details). However, the domain is rapidly evolving and new investment vehicles are developing, and numbers should therefore be seen as estimates.

These estimates show that in 2019 only 14% of total global investments were linked to any form of "green" label. In terms of debt, while "green" or "sustainability"-linked loans and bonds have experienced significant growth, they represented less than 0.5% of total debt issued. The equity side shows higher figures. Much higher proportions (32%) of the $95 trillion of total equity in 2019 were "green." However, it is important to unpack what this figure represents.

The bulk of green equity investments are in shares of listed companies that were deemed to be associated with any of the following procedures: positive, negative, or norm-based screening; any type of ESG integration; sustainability-themed (impact) investment; or engagement and shareholder action.[85] Taken together these stretch "sustainable investments" to include a vast array of investment strategies with arguably very different capacities to achieve sustainable outcomes. In fact, the sustainability outcomes of several of the strategies listed under the "ESG" banner, such as positive/best-in-class screening, are elusive. For example, it is questionable whether positive screening in fossil-intensive industries or industries with very high deforestation risks can meaningfully contribute to sustainability, as they provide merely relative measures. Without a clear benchmark against which to judge the actual negative and positive contribution of a company to a particular variable, like $CO_2$ or total area deforested, this type of screening provides a false sense of security in the progress of sustainable investment. Process-related ESG investments (such as active ownership and shareholder action) display similar problems. They capture (at best) only relative improvements, as owner engagement may not result in significant improvement of company practices, and are rarely associated with any clearly specified or time-bound targets.

These examples of ESG-associated strategies show the muddling of progress toward sustainability that has occurred when equity investments that are defined on the basis of what they (will) achieve (i.e., targets) are counted alongside capital that is associated with a particular process (like engagement) and/or captures only relative improvements (best in class). Along with the fact that current ESG metrics are not designed to capture externalities, it puts into question the ability of the rapidly growing proportion of green equity to rapidly move the needle in favor of sustainability.

Debt instruments offer a potentially more impactful way for financial services to contribute to change. Only a portion of the world's businesses are listed, meaning shareholder influence is not an option to affect performance. Patterns of ownership vary across sectors, but in the Brazilian soy production directly influencing the Amazonian tipping point discussed above, three of the five largest traders, controlling over 50% of the market, are private,[25] and in global seafood, a sector suffering from significant illicit behavior and resultant overfishing, a significant proportion of large operators are private.[86] For these private companies debt is a powerful lever.[87] Even among listed companies, debt provides a key source of capital for operations, and increasing attention is directed at lenders as accountable for the activities of their borrowers. This has spurred incentives to incorporate ESG risk into pricing and even lending criteria (via loan covenants) in both the European Union and the United States.[88–90] In 2010 only a minority of banks globally reported conducting systematic environmental examination of loans, credits, and mortgages.[91] A decade later the discourse has changed. Central banks and regulators are now exploring mandatory climate risk disclosures and climate stress testing, while the Network for Greening the Financial System supports integrating climate risk into financial stability monitoring and supervision. However, these initiatives are

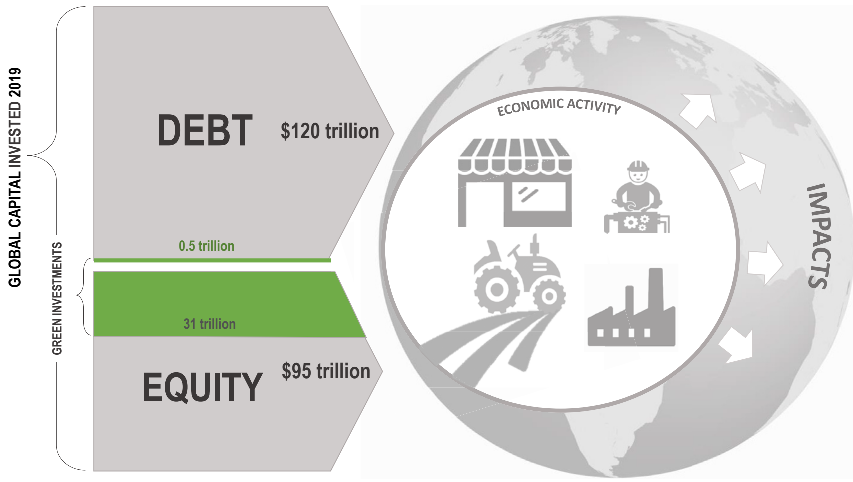


**Figure 4. Overview and comparison of sustainable and mainstream capital flows in 2019**

The figure summarizes the most widespread types of sustainable investment instruments across the categories debt and equity for which statistics or estimates are publicly available. "Mainstream finance," against which sustainable investments are compared, includes the combined estimates of global equity (publicly and private) and total global debt securities (see supplemental experimental procedures for details).

premised on the same skewed risk frameworks as outlined above. Furthermore, as long as central banks continue to conceptualize prudential regulations as "blunt instruments for dealing with climate-related externalities,"[44] and maintain that "adapting capital requirements to reflect externalities could undermine their primary purpose, or give rise to undesirable effects,"[44] it is questionable whether these efforts can become little more than a rearranging of the proverbial deck chairs of the ill-fated *Titanic*.

## A VISION TO LEVERAGE INVESTOR INFLUENCE TOWARD SUSTAINABILITY

Climate stability is a service provided by a healthy biosphere, through complex interconnections between land, water, and atmosphere.[4,11] At 1.2°C the world is already witnessing increasing extremes in our regional weather patterns, while large-scale simplification of ecosystems and loss of biodiversity[92] are increasing the risk of new infectious diseases developing and spreading.[93,94] These large-scale environmental changes are triggering significant perturbations to economies and societies and affecting the financial sector through increasing insurance payouts, disruptions of supply chains, and whole markets.[44,54,57,58]

At this point in history, societies and economies therefore need a financial sector that supports a transition toward a regenerative real economy building a resilient biosphere and that reduces and mitigates current harm to the planet, thereby reducing the risk of cascading and systemic shocks (cf. Sandberg).[95] Strengthening biosphere resilience through active stewardship in this way would also strengthen the financial sector in the long term. The rapidly developing sustainable finance agenda is a response to this growing awareness. However, mainstream approaches for delivering on sustainability ambitions (such as ESG) are on a trajectory that is currently off the mark (heading toward (A) as opposed to (D), Figure 5). This is associated with dual risks.

The first risk is that of transgressing planetary boundaries and aggravating environmental (and arguably social) decline by not including and accounting for relevant externalities (Figure 2). Morningstar's globe rating tool is a prominent example of the significant efforts currently devoted to building a sustainable financial investment infrastructure, and calls for standardizing ESG have been heard for years in the corporate sector as a means to move in the right direction.[96] Yet, refining ESG metrics without incorporating measures of impact will increase precision (Figure 5, B → A), but fail to address accuracy (B → C). In other words, making us more precisely wrong, instead of generally (or even precisely) right.

De Bruin[97] examines the risk in finance associated with misalignment between purpose and action, by using the example of doctors prescribing drugs. Medical doctors, he suggests, are expected to understand and convey the risks of drugs as well as the reason for taking them. Similarly, promoters of ESG-related investments should arguably be aware of, and accountable for, the risks posed to investors and society if the accuracy with which they can address the sustainability problem (akin to a societal ailment) is overstated and thus, in fact, likely to increase the root problem. When they are not, the situation gives rise to the second risk, which is a gradual erosion of confidence and trust.

Trustworthiness of finance comes from clearly articulating what is required to reach the stated ambitions, and to then perform the duties that these requirements imply, and accounting for how they are executed.[98] This is the foundation of the social license to operate of the finance sector.[98] If this process is undertaken in ways that suppress or omit an intelligible account of what ought to be done, it is in fact unintelligent accountability and it risks triggering a "crisis of trust."[98]

Failure to align purported motivations with actions created such a trust crisis in and reduced the credibility of the financial sector following the financial crisis in 2008.[97] Today, unintelligent accountability appears to be rising in the financial sector, as a result of misalignment between sustainability ambitions and current risk frameworks and risk assessment measurements. This hampers the crucial role finance can and needs to play.

Shifting financial sector norms and practices is therefore not about altruism, but about self-perseverance. It necessitates a move toward hard-wiring structures and processes that ensure capital is allocated to activities that can promote long-term biosphere resilience (doing good), while simultaneously reallocating it away from that which is doing harm.

Biosphere stewardship—nurturing the resilience of the Earth system with people as part of it—is increasingly discussed as

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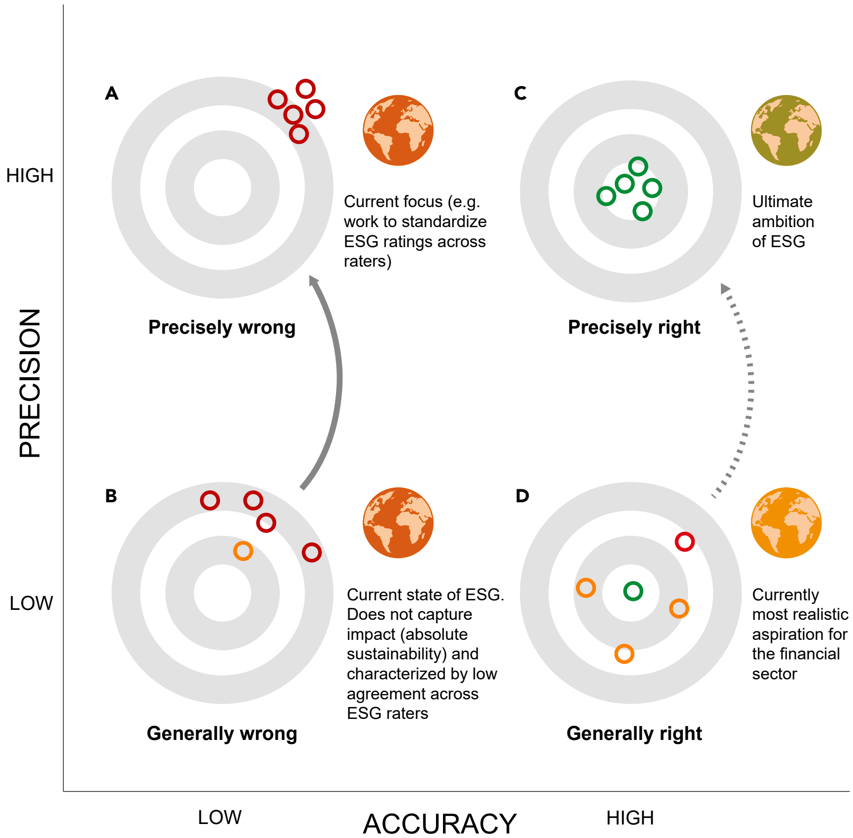


**Figure 5. Accuracy and precision of current sustainable finance approaches (notably ESG) in relation to declared sustainability ambitions**

(A–D) Precision is the closeness of any measurements to one another, while accuracy is the closeness of the measurements to a specific desired value. The likely environmental sustainability risk incurred by an ESG focus is indicated by colored globes, where red indicates high risk of transgressing planetary boundaries, yellow indicates lower risk, and green indicates low risk (best possible option). (B to A) The solid arrow indicates the trajectory currently being pursued, while (D to C) the dashed arrow represents the desired trajectory.

a critical strategy to enhance biosphere integrity for a prosperous future.[99] Recently, such stewardship was proposed[100] as a means to shift corporate norms from excessive, wasteful, and imbalanced consumption founded on a fossil-fuel-driven economy into a renewable-energy-based economy of low waste and circularity within a broader value foundation beyond profit alone. It explicitly acknowledges that people and economies are intertwined with the biosphere and a global force in shaping its dynamics.

To navigate the future, the financial sector needs a similar unifying vision that allows it to leverage its power and influence as a force for sustainability, while fulfilling its mandate to generate returns.[24] A first step toward such financial biosphere stewardship is articulating the need to adjust practices to allow an assessment of where society and economies are heading in relation to key global challenges. It requires addressing the current misalignment between articulated ambitions toward sustainability and the means pursued to achieve them.

Our analysis has highlighted three key actions that will support the financial sector in bridging this gap: (1) recognizing a wider set of Earth system processes (including the climate and hydrological flows in addition to GHGs); (2) acknowledging that current risk frameworks lack an acknowledgment of the risk of aggravating climate and large-scale environmental change through investments; and (3) moving to develop impact accounting systems that cut across all financial investments and become a core part of capital allocation decisions. Doing this will require forging new alliances between science and finance, but also new transdisciplinary research to assist finance in developing risk management tools to better address the Anthropocene reality and ensure that the development of impact accounting is grounded in both social and environmental sustainability science.

## EXPERIMENTAL PROCEDURES

### Resource availability

#### *Lead contact*

Further information and requests for resources should be directed to and will be fulfilled by the corresponding author, Beatrice Crona, beatrice.crona@su.se.

#### *Materials availability*

Supplemental experimental procedures and datasets generated during this study are deposited at https://doi.org/10.7910/DVN/7RY1T9, but restrictions to the use of the Eikon Refinitiv data apply as these were obtained under paid license.

#### *Data and code availability*

Data to reproduce Figure 3 can be obtained from https://doi.org/10.7910/DVN/7RY1T9. "Deforestation risk scores" were obtained from Forest 500 (https://forest500.org/) and compared with the Refinitiv Eikon "environmental pillar score" (representing the environmental part of the total ESG) using Spearman rank correlation. Deforestation risk scores represent an assessment of a company's overall approach to dealing with deforestation risk, including an aggregate score for all commodities in which the company is trading. Additional information on the data sources and assumptions is in the supplemental experimental procedures.

Data for Figure 4 consist of estimates of green and mainstream corporate investments estimated by collating publicly available information on capital allocated under the broad categories of debt and equity. These can be obtained from the supplemental experimental procedures and https://doi.org/10.7910/DVN/7RY1T9. For each investment instrument we provide estimates of total capital allocated during 2019. To estimate the proportion of "green" over total capital allocated in 2019 we divided "green" debt by total debt outstanding in 2019 and "green" equity by total equity invested in 2019. Details of calculations, and all definitions of investment instruments, are elaborated in the supplemental experimental procedures.

## SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.oneear.2021.04.016.

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## AUTHOR CONTRIBUTIONS

Conceptualization, B.C. with support from other authors; methodology and analysis, B.C.; writing, all authors; visualization B.C.; funding acquisition, all authors.

## DECLARATION OF INTERESTS

The authors declare no competing interests.

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