

PERSISTENT BUSINESS BLIND SPOTS ON CLIMATE RISK AND ADAPTATION

Allie Goldstein

Executive Summary

The world's largest companies rank climate change as the most impactful global risk, but in reporting to investors, companies continue to underestimate and underreport on these risks, especially in their supply chains. This brief assesses companies' progress against the five major climate change risk and adaptation blind spots that the author first identified in a Nature Climate Change study that comprehensively examined 2016 CDP disclosures (mostly of 2015 data). Here, the blind spots are revisited using 2018 CDP disclosures (mostly of 2017 data). Notably, the recommendations of the Financial Stability Board's Task Force on Climate-related Financial Disclosures in 2017 led to a slight uptick in the reporting on the financial impacts of climate risks and the costs of managing them, but this financial information remains unstandardized and difficult to interpret. The brief examines three uniquely vulnerable agricultural commodities—cocoa, coffee, and cotton—all of which are mostly grown by smallholder producers and face projected declines in yield and quality due to climate change. Companies involved in cotton, coffee, or cocoa value chains collectively reported \$1.1 billion in climate change impacts and \$0.4 billion in costs to manage the impacts. Despite their reliance on ecosystem services, particularly at the production end of their value chains, few companies sourcing these agricultural commodities are using ecosystem-based adaptation strategies to build their resilience.

About this paper

This paper is part of a series of background papers commissioned by the Global Commission on Adaptation to inform its 2019 flagship report. This paper reflects the views of the authors, and not necessarily those of the Global Commission on Adaptation.

THE STATE OF CORPORATE REPORTING ON CLIMATE RISKS AND ADAPTATION

The Global Commission on Adaptation's 2019 report finds that "adapting now is in our strong economic self-interest" and that proactively investing \$1.8 trillion over the next decade in five key areas could yield \$7.1 trillion in benefits.¹ While governments will play a strong role in driving this transition, the private sector also has considerable power and responsibility—and proactively adapting to climate change is in companies' best interest. The World Economic Forum's annual survey of business leaders found that climate change was of great concern in 2020: failure of climate action was rated as the most impactful global risk and "climate change is striking harder and more rapidly than many expected".² Yet recent research has shown that the world's largest companies are underpreparing for climate change risks and underreporting on them to investors.³ This failure to see the severity and interconnectedness of climate change impacts becomes obvious when companies such as PG&E, California's largest utility and a company that actually published a detailed resilience plan in 2016⁴, file for bankruptcy over wildfires exacerbated by climate change. The United Nations estimates that climate change risks could cost companies \$1.2 trillion over the next 15 years.⁵

The Task Force on Climate-related Financial Disclosures (TCFD), formed in 2016 under the Financial Stability Board, has tried to address the "tragedy of the horizon", or the idea that, by the time climate change risks majorly hit financial systems, it will be too late to reverse many impacts. The TCFD identifies two major categories of risk: (1) transition risk, or the policy, legal, technology, and market changes required to address mitigation and adaptation requirements and (2) physical risk, or the acute and chronic shifts in climate patterns. The recommendations the TCFD released in 2017⁶ called for companies to disclose climate change risks in mainstream financial filings and to do so more systematically. A recent review of 1,100 companies by the TCFD found although corporate disclosures on climate-related risks have increased since the recommendations were released, they remained low overall, with only a quarter of companies addressing at least five of the TCFD's 11 categories of disclosures.⁵

Prior to TCFD, CDP, a non-profit that runs a global disclosure system on environmental issues, was the main touchstone for corporate disclosures on climate risk. CDP revised its questionnaire to align with the TCFD recommendations, and its annual climate questionnaire remains the best source of information for aggregated, publicly accessible disclosures. In 2018, CDP's climate questionnaire included 6,937 companies; 2,548 companies disclosed publicly. This brief uses these public disclosures to understand how corporate reporting on climate risk and adaptation has evolved (or not) in the last several years, and what blind spots persist, with a deep dive on supply chain risks to key agricultural commodities: coffee, cocoa, and cotton

PERSISTENT BLIND SPOTS

Our study of 2016 corporate climate change disclosures to CDP (on 2015 data) found that companies had a range of 'blind spots' in their assessments of climate change impacts and in their development of strategies to manage them.³ These 'blind spots' were:

1. Companies underestimated the magnitude of physical climate change risks.
2. Companies underreported supply chain risks.
3. Companies had a bias towards 'soft' and 'hard' adaptation strategies while underrecognizing the potential of ecosystem-based adaptation.
4. Companies often failed to report on the costs of adaptation.
5. Few companies grappled with the possibility of nonlinear climate change and its impact on business.

This refreshed analysis based on 2018 CDP disclosures shows that companies continued to report a wide range of current and potential climate change risks, with 62% of publicly disclosing companies reporting at least one climate change risk. Overall, 52% of companies reported at least one transition risk (such as new policies or changing consumer behavior) and 47% reported at least one

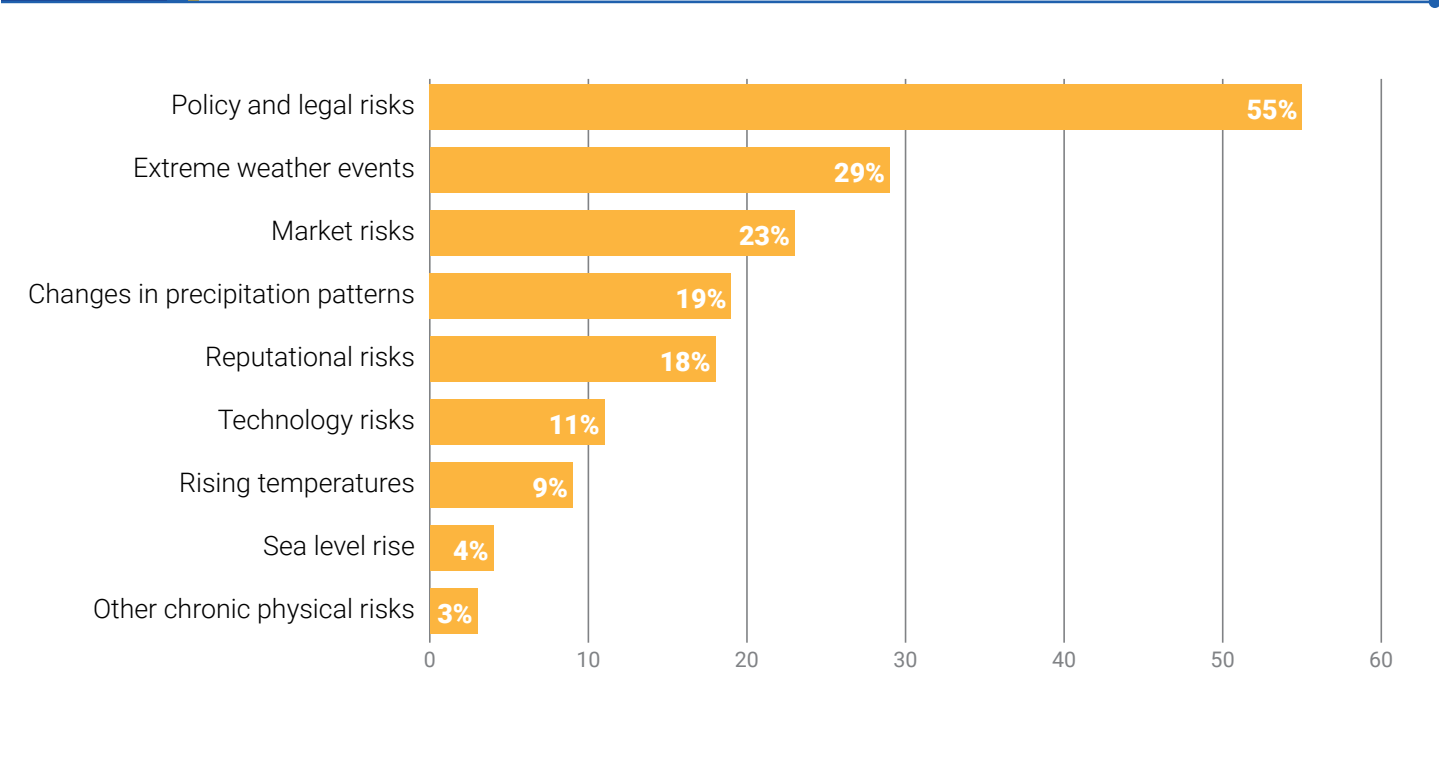
physical risk (such as sea level rise, changing precipitation patterns, or extreme heat). Overall, companies have ‘closed the gap’ on some of the blind spots, with, for instance, the proportion of companies reporting a value for the financial implications of climate risk doubling. But significantly more action is needed to align corporate reporting and strategies with the scale of the climate challenge, particularly in terms of supply chain risk and non-linear climate impacts

UNDERESTIMATING THE MAGNITUDE OF PHYSICAL RISK

Companies continue to underestimate the magnitude of physical climate change risks, reporting ‘transition’ risks such as policy changes and shifting markets at about twice the rate as physical risks such as extreme heat, changing precipitation, and storms (Figure 1). In some cases, this could reflect that the costs of regulation logically precede the costs of the physical impact they are designed to mitigate. However, it also likely reflects a corporate bias towards assessing the risks associated with shifting policies and markets (something companies usually already do) whereas assessing the risks associated with a

physically shifting climate requires new models and tools. In an analysis of 500 of the world’s largest companies by market capitalization, CDP found that many apparel, food, beverage & agricultural and infrastructure industries identified only physical risks whereas many fossil fuel and materials companies reported only transition risks.⁷ As shown in Figure 1, companies may more readily recognize risks due to extreme weather events—a business disruption—whereas chronic physical risks such as rising temperatures and sea level rise are reported less often. Are these risks truly less prominent, or are they simply harder to characterize and therefore underestimated? New research shows that it may be the latter. One study modelling climate change impacts out to 2060 found that damages from physical impacts such as changes in crop yields, changes in fisheries, and changes in health care expenditures from diseases and heat stress are projected to rise twice as fast as global economic activity, reaching 1.0-3.3% of GDP by 2060.⁸ Another study looking just at sea level rise estimated that global warming above 2° C could result in US \$14-27 trillion in annual flood damages, reaching 2.8% of global GDP in 2100.⁹ Physical risks of this magnitude would surely hit the private sector but are not yet captured in corporate disclosures.

FIGURE 1 Percentage of companies facing various risk drivers



UNDERREPORTING SUPPLY CHAIN RISK

More companies (20%) identified supply chain risks in 2018, up from 15% in 2016. Though an improvement, this is still likely an under-recognition of risks ‘beyond the fenceline’ which may affect everything from transportation routes to the availability of raw materials to customers’ demand for products to employees’ ability to get to work.

A new question in CDP’s survey allows us to look at the specific ways in which companies are engaging their suppliers to address climate change risk. The most common type of engagement was through supplier compliance and onboarding, with 15% of companies including climate change in supplier selection or management mechanisms, evaluation processes, or codes of conduct/ Key Performance Indicators. Fourteen percent of companies collected climate change information at least annually from suppliers. Fewer companies (8%) attempted to change supplier behavior through supplier award schemes, financial incentives, or engagement campaigns, and even fewer (6%) worked to change markets through innovation and collaboration with suppliers. Much of the reported supplier engagement focused on understanding and reducing suppliers’ greenhouse gas emissions.

BIAS TOWARDS TRADITIONAL APPROACHES AND AN UNDERUTILIZATION OF ECOSYSTEM-BASED ADAPTATION

The conservation, restoration, and sustainable management of ecosystems can reduce various physical impacts of climate change, including to business. For example, in Latin America, 91% of the suitable area for growing coffee is within 1.6 km of a forest, indicating an important link between pollinator habitat and the crop—and making forest conservation essential as coffee suitability areas shift.¹⁰ However, ecosystem-based adaptation (EbA) is rarely used by companies compared to the prevalence of ‘soft’ adaptation processes that are substantive yet physically intangible responses to climate impacts (e.g., emergency planning, employee training, shifting investments) and ‘hard’ adaptation approaches encompassing capital investments in technology or engineered infrastructure.³

Current corporate reporting on climate risk management does not lend itself to a quantitative analysis of how many companies are using different adaptation strategies, however, a review of the adaptation strategies of the 44 companies active in the coffee, cocoa, or cotton supply chain found that only seven (16%) cited ecosystem-based approaches to managing climate change risks. For example, to manage dwindling water availability in California, Olam International supported headwaters and meadow restoration projects in the Sierra Nevada. Farmer Brothers used EbA to address both policy-related and physical climate change risks: In anticipation of rising carbon pricing, the company introduced a composting program to reduce the need for carbon-intensive fertilizer; to mitigate rising temperatures, the group is testing a new coffee varietal for drought and disease resistance. Overall, though, more companies active in key agricultural supply chains reported soft approaches, from locking in contracts with yarn suppliers (Hanesbrands Inc.) to diversifying raw material sourcing (Firmenich SA) to assessing customer willingness to pay for sustainable chocolate (Barry Callebaut). While strategies such as geographically diversifying sourcing are effective to some extent, direct investments in farmers and agricultural landscapes will be increasingly necessary as climate change begins to affect entire regions and commodities—therefore limiting the efficacy of supplier diversification.

GAPS IN QUANTIFYING COSTS

In 2018, 42% of publicly-disclosing companies reported dollar values for the financial implications of climate risks, up from 21% in public disclosures in 2016.* Similarly, 38% of companies reported on the cost of managing climate risks, up from 27% three years ago. More than a third (35%) of companies reported both financial impacts and management costs. These increases were likely due to companies’ response to the TCFD recommendations released in June 2017, which led to increased investor pressure as well as CDP’s improved survey design, which encouraged the reporting of raw financial values. Still, more than half of companies failed to quantify the financial implications of

*For all disclosures it was 31% in 2018, but this analysis considers only public disclosures for apples-to-apples comparison to the 2016 data.

climate change to their business, and the values reported ranged widely in terms of their scope (single product vs. entire industry), timing (one-day shutdown vs. years-long planning process), and certainty (already experienced vs. future). The values that were reported were largely unstandardized, and few were fit-for-purpose for investor decision-making. Notably, as in 2016, 2018's adaptation costs

overwhelmingly captured upfront expenditures without an attempt to directly compare this spending to the costs of other potential adaptation strategies, or to the anticipated impact of risk in the absence of action. The lack of cost-benefit analyses limit investors' ability to understand if an investee's strategy is sufficient for addressing the risk(s) at hand.

Binsar Rajab harvests cocoa from his agroforestry garden in North Sumatra, Indonesia. © Conservation International/ photo by Tory Read



TABLE 1

Examples of the financial implications and management costs of climate change risks as reported by companies to investors (data summarized from public disclosures to CDP in 2018)

Type of risk	Company (Sector, Head-quarters)	Climate risk	Financial implication (US\$ millions)	Description of financial impact	Management cost (US\$ millions)	Description of management strategy & costs
Physical: Chronic	Gold Fields Limited (Mining, South Africa)	Changes in precipitation patterns leading to increased risk of flooding to mine pits and tailings dams	1	Estimated loss due 1-day work stoppage	29	Capital expenditures on water projects in 2017
Physical: Acute	Canadian National Railway Company (Transportation, Canada)	Extreme events including wildfires, extreme heat leading to rail buckling, landslides and mudslides	42	Assessed impact of extreme winter weather in 2017	76	Extreme weather readiness, rail maintenance, inspection programs
Transition: Changing customer behavior	Sony (Electronic equipment, Japan)	Changing consumer behavior associated with climate change awareness	305	Hypothetical impact of a 1% drop in sales due to failure to provide eco-conscious products	0.2	Annual cost of environmental disclosure to mitigate reputational risk
Transition: Policy and legal	LafargeHolcim Ltd (Cement, Switzerland)	Litigation	0	"It is difficult to establish a figure as there are no precedents yet set"	0.1	Increased transparency on carbon and environmental impacts
Transition: Technology	Barilla Holding SpA (Food & beverage, United Kingdom)	EU and national renewable energy and energy efficiency regulations	173	Potential cost of business interruption if factories are not aligned with new regulations	4.6	Capital investments in renewable energy and efficiency; cost assessed for staff and consultants working on energy

For all disclosures it was 31% in 2018, but this analysis considers only public disclosures for apples-to-apples comparison to the 2016 data.

FAILURE TO GRAPPLE WITH NONLINEAR CLIMATE CHANGE

A recent study by leading Earth scientists¹¹ found that “unfortunately, much of the technical advice and recommendations about these risks incorporate assessments of the economic implications that omit or underplay the largest potential impacts of climate change.” The authors argue that impacts that involve thresholds and nonlinear change are often underrepresented in climate models because they are beyond current human experience; however these extreme impacts—including destabilization of ice sheets, stronger tropical cyclones, disruptions to atmospheric circulation, and ecosystem collapse—are entirely possible at higher (and even moderate) emissions scenarios. For example, the Greenland ice sheet is expected to reach a tipping point somewhere between 1 and 4 °C and crossing this threshold could cause 7 m of sea-level rise,¹² affecting hundreds of millions of people living along the coasts.

Overall, company climate disclosures fail to grapple with the potential of nonlinear climate impacts, and as a result most risk management strategies are incremental rather than transformative. Should businesses prepare for nonlinear climate risks? Some business leaders might argue that adapting to risks that are on the outer edge of the probability curve is impractical given fiduciary responsibility to shareholders, or that preparing for extreme risks is instead within the purview of the public sector. However, companies’ default assumption of stable states and linear change¹³ may not match reality, especially as current emissions rates put the world on a trajectory towards 4 °C or higher¹⁴, an average global temperature at which many of the ‘improbable’ risks become much more probable. Business sectors that have a particularly important role in preparing for nonlinear climate impacts include insurance, which society relies on to accurately price risk, and sectors that build long-term infrastructure, such as electrical and water utilities, road transport, and construction.

SPOTLIGHT ON SUPPLY CHAIN RISKS: COTTON, COFFEE, AND COCOA

To better understand whether companies are accurately evaluating and adequately addressing climate change risks within their supply chains, we examined three agricultural commodities with uniquely vulnerable supply chains. Yields and quality of cash crops such as cocoa, coffee and cotton are projected to decline, posing supply risk to buyers and export revenue losses to countries.¹⁵ Risks to local livelihoods are pronounced where production depends on smallholder farmers. Smallholders account for 90 percent of global cocoa production, 80 percent of coffee production, and 75 percent of cotton production.^{16,17,18}

Companies involved in cotton, coffee, or cocoa value chains collectively reported \$1.1 billion in climate change impacts and \$0.4 billion in management costs to CDP in 2018, with a third to a half of reporting companies in each category quantifying these costs. Coffee and cocoa impacts occurred mainly in supply chains as reporting companies faced climate-related crop losses driven mainly by rising temperature (for coffee) and changing precipitation patterns (for cocoa) while reporting cotton companies included more retailers that faced policy and market-related climate risks. Table 2 below provides examples of the climate impacts faced by specific companies.

TABLE 2

Examples of the financial implications and management costs of physical climate change risks as reported by companies involved in major agricultural commodity supply chains (data summarized from public disclosures to CDP in 2018)

	Company (Headquarters)	Climate risk	Financial implication (US\$ millions)	Description of financial impact	Management cost (US\$ millions)	Description of management strategy & costs
Cotton	NIKE (Apparel, United States)	Drought, decreased cotton production	10	Maximum projected impact of decreased margins on cotton products	0.1	Scenario planning to determine at-risk areas of supply chain; Helping suppliers with wastewater recycling
Cotton	Arvind Ltd (India)	Changes in weather patterns and precipitation	2	Projected 10% impact on cotton pricing and availability in medium-term	0.25	Diversifying raw materials sourcing and recycling to reduce consumption of virgin cotton
Cotton	Stockmann Oyj (Finland)	Extreme weather events; Decreased cotton yields	1.2	Impact of potential 1% decrease in revenue from fashion	Not reported	Increased use of organic cotton, which is more resilient
Coffee	Farmer Brothers (United States)	Shifts in coffee suitability	1.5	Potential impact of 1% increase in cost of raw materials	0.05	Pre-competitive collaboration, including by testing resilient varieties
Coffee	Keurig Green Mountain (United States)	Shifts in coffee suitability	Not reported	Frequent supply chain substitutions could lead to cost increases, customer alienation	Not reported	Work with farmers on traceability, compliance with sustainable sourcing standards, and investments in coffee communities
Coffee	J.M. Smucker Company (United States)	Decreased coffee production	Not reported	Increased coffee prices	Not reported, proprietary	Supplier contracts to manage price volatility; Collaboration with supply chain participants; Sponsorship of research on resilient coffee varieties
Cocoa	Barry Callebaut AG (Switzerland)	Shifts in cocoa suitability, drought	349	Potential loss in production capacity associated with 5% drop in global revenue	10.3	Direct engagement with farmers on resilience

Coffee is grown in more than 60 tropical countries on over 11 million hectares by an estimated 25 million farmers, many of them smallholders¹⁹ and is second only to oil in terms of its value as a traded commodity.²⁰ Two main varieties – Arabica and Robusta – dominate the global market and grow at distinct altitudes: Arabica in the highlands between 500 and 1400 meters and Robusta in the lowlands below 500 meters. Suitability ranges are expected to shift dramatically under climate change, with the global area suitable for growing coffee shrinking by about 50% across emissions scenarios.²¹ Arabica coffee will be particularly affected, and coffee-producing countries that do not have many high mountains, such as Nicaragua, El Salvador, Brazil, and Indonesia, are most at risk of losses because coffee cannot simply be planted further uphill as the climate warms.¹⁸ It is unclear whether Robusta could compensate for these losses; though this variety can withstand hotter temperatures, it also needs little intra-seasonal variability and is therefore suited for lower latitudes.¹⁹

Because the lifespan of a coffee plantation is 30 years, and because its production is so dependent on smallholders, coffee requires particularly forward-looking and down-scalable adaptation strategies. Low (500-800 meters) and very high (1400-1600 meters) altitude areas will need to undergo transformative adaptation in which entire landscapes are transformed away from or towards coffee production (with attendant risks to biodiversity and other landscape values). Meanwhile, medium to high (800-1400 meter) altitudes may undergo more incremental adaptation such as crop diversification, a switch to Robusta, shade-grown strategies, or improved pest management.¹⁷ A six-year (2012-2018) research project looked at the adaptation strategies of coffee farmers in Central America, where the crop is especially vulnerable. Surveys of more than 300 farms across six landscapes found that ecosystem-based adaptation (EbA) strategies such as agroforestry systems that buffer against high temperatures and live fences to prevent soil erosion are particularly important for farmers who lack the resources and capacity to implement other adaptation approaches such as purchasing new seed varieties, increasing fertilizer use or irrigation, or purchasing crop insurance. Researchers found that these EbA strategies could be expanded if farmers had access to credit, technical assistance, and agricultural extension services, and if smallholder land tenure was expanded, giving farmers more incentive to maintain tree cover on their land.²² Climate modelling could also be beneficial in informing crop diversification based on shifting suitability ranges.²³

Large coffee brands and retailers can support on-farm adaptation through supplier engagement programs that reach the farm level. For example, Starbucks' C.A.F.E. ethical coffee purchasing program now has 318,000 participating farms and includes climate-friendly practices such as shade-grown coffee and pest management; the company has also distributed coffee rust-resilient varieties to farmers. Olam International, through the Olam Livelihood Charter, in 2017 trained more than 55,000 smallholder farmers on climate-smart practices; the company also has a Supplier Code that allows them to engage all suppliers on climate change as part of their contractual agreements.

Coffee beans in Chiapas, Mexico. © Conservation International / photo by Miguel Ángel de la Cueva



CONCLUSION

The TCFD's call to action on corporate climate disclosures in 2015 followed by their recommendations in 2017 led to an uptick in certain aspects of corporate reporting, as assessed through the disclosure platform CDP. Between the 2016 and 2018 CDP disclosure cycles, the proportion of companies attempting to assess a dollar value for the financial implications of climate risk rose by 21 percentage points; meanwhile 11% more companies assessed the costs of their risk management strategies. While this is important progress, still more than half of companies identified climate risks without quantifying their financial impact. The dollar values that are reported are unstandardized, referring to a wide range of risks, timeframes, and likelihoods. This makes difficult for anyone—and especially investors—to compare across companies or sectors. Though CDP supply chain risk reporting increased since the TCFD recommendations came out, this uptick was slight – 20%, up from 15%. However, a deep dive into companies in the coffee, cocoa, and cotton sectors reveals that they are using a range of interesting adaptation strategies, from direct engagement with farmers to diversifying suppliers to pre-competitive collaborations on resilient crop varieties.

While the TCFD's recommendations gave companies an important 'push' towards better climate reporting, these have yet to become a standard or standardized part of financial disclosures. This is unsurprising given that these disclosures remain largely voluntary. However, there are increasing signs that government regulation and investor demand will lead to more and better disclosure. France and the United Kingdom have written (at least some aspects of) corporate climate disclosures into regulation.⁵ The Network for Greening the Financial System (NGFS), made up of 36 central banks, has also embraced the TCFD recommendations,²⁴ putting increasing pressure on companies.

The question, really, is whether the normalization and standardization of corporate climate change disclosures will move fast enough for investors to shift their money out of high-risk companies and incentivize adaptation at a meaningful scale. As a 2019 CDP report points out, "if the finance sector is identifying more risks for their clients than the companies report themselves, regulators and investors

should be asking as to who is actually managing these risks."⁹ Periodic and comprehensive assessments of corporate climate risk reporting can help tell us how far we've come towards closing the gap on corporate blind spots.

METHODOLOGY

This summary of private sector climate change risks is derived from companies' responses to CDP's 2018 climate change questionnaire on behalf of a network of investors representing over \$100 trillion. 6,937 companies responded to the questionnaire in 2018 (reporting mostly on 2017 data); of these, 2,548 responses were public. This analysis is based off of those public responses.

To analyze climate change risks to agricultural commodity supply chains, we identified companies that listed cotton, coffee, or cocoa as an important commodity produced or sourced in question AC0.7_C-FB0.7_C-PF0.7_C1 or that named one or more of these commodities in a textual description of major risks faced. This resulted in a more detailed analysis of 44 companies: 13 active in the coffee supply chain, 10 active in the cocoa supply chain, and 25 active in the cotton supply chain (4 companies were active in multiple agricultural commodity supply chains).

All financial values were converted to USD based on Oanda Currency Converter (<https://www1.oanda.com/currency/converter/>) using September 12, 2018 conversion rates, since that is the date the CDP survey was due. To avoid overestimation of both the financial impact of climate risks and its management costs, we manually checked all values over \$1 billion USD; some were revised based on the textual description (e.g., if the numerical value entered was an order of magnitude off from the value described in the text) and others were excluded if unconfirmed by the textual description and deemed infeasible (e.g., if the company reported a financial impact several times the annual revenue of their company). This 'cleaning' of the data resulted in \$965 billion excluded from the financial impact total and \$37 billion excluded from the management cost total. Reported values are therefore conservative.

ENDNOTES

- 1 Global Commission on Adaptation and World Resources Institute. *Adapt Now: A Global Call for Leadership on Climate Resilience*. September 2019. https://cdn.gca.org/assets/2019-09/GlobalCommission_Report_FINAL.pdf
- 2 World Economic Forum. *The Global Risk Report 2020: 15th Edition*. Geneva, Switzerland. 2020. http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf
- 3 Goldstein A, Turner W, Gladstone J, Hole DG. 2018. The private sector's climate change risk and adaptation blind spots. *Nature Climate Change*.
- 4 Pacific Gas and Electric Company. *Climate Change Vulnerability Assessment and Resilience Strategies*. November 2016. http://www.pgecurrents.com/wp-content/uploads/2016/12/PGE_climate_resilience_report.pdf
- 5 Task Force on Climate-Related Financial Disclosures. *2019 Status Report*. June 2019. <https://www.fsb-tcfd.org/publications/tcfd-2019-status-report/>
- 6 Task Force on Climate-Related Financial Disclosures. *Recommendations of the Task Force on Climate-Related Financial Disclosures*. June 2017. <https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-2017-TCFD-Report-11052018.pdf>
- 7 CDP. *Major risk or rosy opportunity: Are companies ready for climate change?* 2019. <https://www.cdp.net/en/research/global-reports/global-climate-change-report-2018/climate-report-risks-and-opportunities>
- 8 Dellink, R., Lanzi, E. & Chateau, J. The Sectoral and Regional Economic Consequences of Climate Change to 2060. *Environmental & Resource Economics* **72**, 309-363, doi:10.1007/s10640-017-0197-5 (2019).
- 9 Jevrejeva S, et al. 2018. Flood damage costs under the sea level rise with warming of 1.5 °C and 2 °C. *Environmental Research Letters*.
- 10 Imbach P, et al. 2017. Coupling of pollination services and coffee suitability under climate change. *PNAS*.
- 11 Defries, R, et al. The missing economic risks in assessments of climate change impacts. London School of Economics and Political Science and Grantham Research Institute on Climate Change and the Environment. September 2019. <http://www.lse.ac.uk/GranthamInstitute/publication/the-missing-economic-risks-in-assessments-of-climate-change-impacts/>
- 12 Oppenheimer, M. et al. in *Climate Change 2014: Impacts, Adaptation, and Vulnerability* (eds Field, C. B. et al.) 1039–1099 (IPCC, Cambridge Univ. Press, 2014).
- 13 Winn, M. I., Kirchgeorg, M., Griffiths, A., Linnenluecke, M. K. & Gunther, E. Impacts from Climate Change on Organizations: a Conceptual Foundation. *Business Strategy and the Environment* **20**, 157-173, doi:10.1002/bse.679 (2011).
- 14 World Bank. *Turn Down the Heat: Confronting the New Climate Normal*. November 2014. <https://www.worldbank.org/en/topic/climatechange/publication/turn-down-the-heat>
- 15 FAO (2018) *The State of Agricultural Commodity Markets 2018*. Agricultural trade, climate change and food security. Rome.
- 16 Fairtrade Foundation (2019) Cocoa farmers. Available at: <https://www.fairtrade.org.uk/Farmers-and-Workers/Cocoa>
- 17 Fairtrade Foundation (2019) Coffee farmers. Available at: <http://www.fairtrade.org.uk/Farmers-and-Workers/Coffee>
- 18 IDH (2019) Cotton: Retailers and brands investing in a mainstream sustainable cotton market. Available at: <https://www.idhsustainabletrade.com/sectors/cotton/>
- 19 Läderach P, et al. 2017. Climate change adaptation of coffee production in space and time. *Climatic Change* **141**:47-62.
- 20 Ovalle Rivera O, Läderach P, Bunn C, Obersteiner M. 2015. Projected Shifts in *Coffea arabica* Suitability among Major Global Producing Regions Due to Climate Change. *PLOS One*.
- 21 Bunn C, Läderach P, Ovalle Rivera O, Kirschke D. 2015. A bitter cup: climate change profile of global production of Arabica and Robusta coffee. *Climatic Change* **129**: 89-101.
- 22 Harvey C, et al. 2017. The use of Ecosystem-based Adaptation practices by smallholder farmers in Central America. *Agriculture, Ecosystems and Environment* **246**: 279-290.
- 23 Hannah L, et al. 2017. Regional modeling of climate change impacts on smallholder agriculture and ecosystems in Central America. *Climatic Change* **141**: 29-45.
- 24 NGFS, A call for action: *Climate change as a source of financial risk*. April 17, 2019. Available at: https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf