

ASSESSING PHYSICAL RISKS OF GREEN BONDS: A CASE STUDY





Executive summary

The green bond is one of the fastest-growing instruments in sustainable finance and, as such, has been subject to extensive development of its reporting frameworks in recent years. Green bond disclosure and reporting includes proceeds allocation and impact reporting—quantitative impact indicators, such as avoided emissions and/or energy saved, are now readily available. However, this information sheds little light on the exposure, vulnerability and resilience of green bond projects to climate events, or how they compare to those of other issuers. Green bonds may provide financing to assets that contribute to a low carbon, climate resilient (LCCR) economy (Nicol, Shishlov and Cochran, 2018), but the assets can be just as vulnerable to the physical risks of climate change as non-green assets.

Although bonds, given their maturity, may be less exposed to the potential physical risks of climate change in the short term, certain green assets are considered high risk due to their location or type. With climate-related risks affecting revenue generation assets (factories, power plants, mills, etc), the financial stability of some issuers could be compromised. As recommended by the Financial Stability Board's (FSB) Task Force on Climate-related Financial Disclosures (TCFD, 2017), investors should have a greater understanding of their investments' exposure to climate risks, as well as the potential impact of these risks.

South Pole, in collaboration with Affirmative Investment Management (AIM), has conducted ground-breaking work to develop, test and implement climate-related risk assessment and to inform green bond analysis and disclosure. Forward-looking risk assessment can be used to highlight the resilience of green bonds as an investment strategy, and to identify opportunities

and risks. Improved reporting on climate-related risk, and the adaptive capacity of projects, can benefit both issuers and investors.

South Pole's climate risk screening tool combines a wealth of climate change expertise and investment impact analysis with the application of state-of-the-art climate models. The approach takes into account the TCFD recommendations, applying forward-looking analysis to evaluate the level of exposure to physical risks for green bond issuers and their use of proceeds (projects), enabling comparisons between green bond frameworks and the issuers overall, as well as with non-green bond issuers. By assessing the exposure to climate risk of green bond frameworks, investors are able to consider a green project's risk exposure against its positive impact. Furthermore, the assessment of an issuer's climate risk profile provides insight into the issuer's level of alignment to a low carbon and climate resilient future.

Standard practices for green bond disclosure on forward-looking assessments or climate-related risk identification are yet to be established; also, very few issuers are currently reporting on adaptive measures or strategies for their use of proceeds. AIM and South Pole have developed and applied the climate risk assessment tool for green bonds to encourage greater disclosure on climate risks and adaptive capacities of green bond issuers, at both the framework and issuer level. As demonstrated in this case study, climate risk assessment can be a powerful engagement tool, encouraging dialogue on the subject between issuer and investor, and highlighting the importance of climate risk considerations in investment decision making.

Introduction - An investor's perspective on why physical risk assessment is important

The year 2018 saw multiple weather records broken, with the increasing frequency of extraordinary weather events causing devastation around the globe and the loss of thousands of lives. Wildfires raged in Europe, floods devastated parts of India and the US, hurricanes swept across the Americas and Caribbean, and extreme heat waves were experienced throughout the northern hemisphere.

The fifth IPCC Special Report, published last year, warns of devastating consequences should global warming reach 1.5°C above pre-industrial levels. Warming already caused by anthropogenic greenhouse gas emissions will persist for centuries to millennia, and will continue to cause further long-term changes in the climate system. Are we prepared?

It has become evident that climate-related risks will increase considerably as the planet continues to warm. These will differ, subject to a variety of potential global warming scenarios and are highly geographically specific, with varying vulnerabilities around the globe. For example, low-lying coastal areas may be liable to flooding and land loss, while some regions will be vulnerable to drought and wildfires.

Given the variations in climate risk we, as investors, must question how well we understand its myriad implications. Extreme weather events, such as floods and droughts, have a financial impact and increased knowledge about climate risk can help to improve the resilience of our investment portfolios. More importantly, understanding climate risk can help us to assist vulnerable communities to be better prepared and more resilient.

Building on the definitions presented by the TCFD, climate risks can be understood in two primary categories: 1) transition risk—the implications of a low carbon transition; and 2) physical risk—the impact of extreme events and changing weather patterns.

The investment community's focus on climate risk has, until recently, been largely preoccupied with transition risk—our global efforts and strategy to limit greenhouse gas emissions to a below 1.5°C or 2°C warming scenario to avoid increased severity and frequency of physical climate events. However, research indicates that the Earth has already warmed by 1°C versus pre-industrial levels, resulting in the climate change that has given rise to, or exacerbated, extreme weather events. Our ability to assess the investment implications of physical risks is underdeveloped and the danger that we collectively fail to meet our global obligations in order to limit warming by 2°C this century remains.

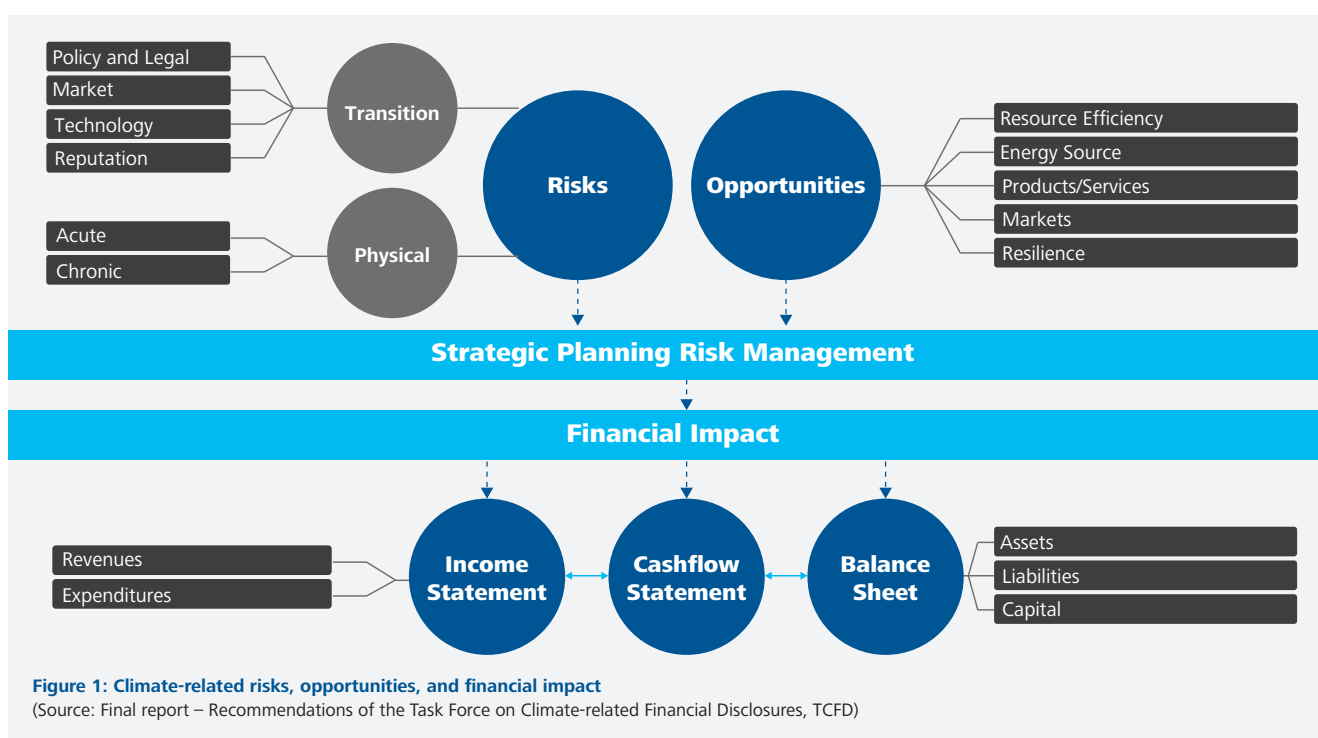
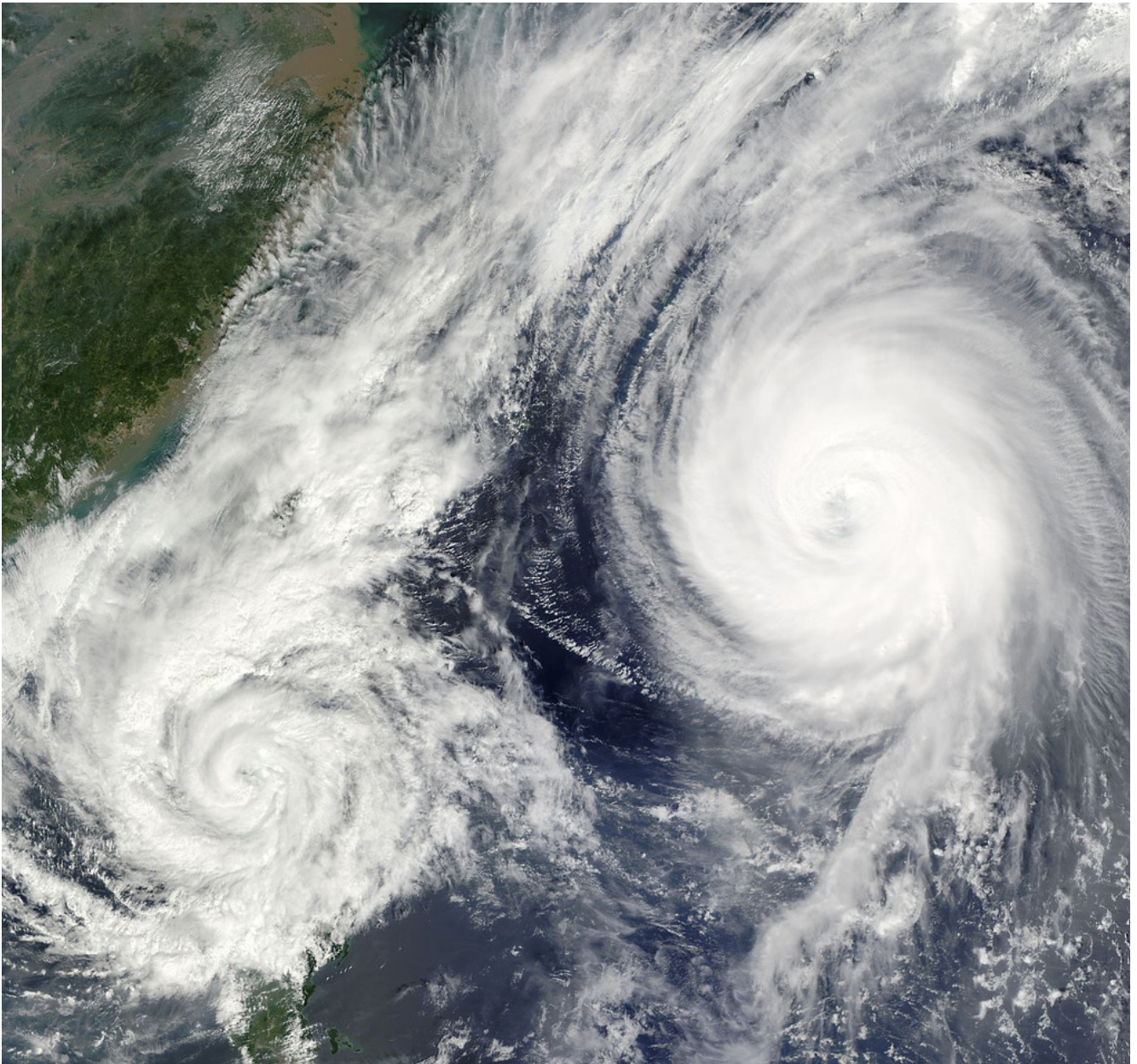


Figure 1: Climate-related risks, opportunities, and financial impact

(Source: Final report – Recommendations of the Task Force on Climate-related Financial Disclosures, TCFD)



Green bonds—self-labelled bonds with a defined use of proceeds towards low carbon and/or environmental activities and sectors—are one of the major success stories in terms of innovation supporting green finance flows in recent years. There are many reasons why this fast-growing, emerging asset class can be an effective tool in helping manage climate risks.

Affirmative Investment Management (AIM) has been working with the leading climate experts at South Pole to develop a tool to understand green bond exposure to physical risks and improve green bond reporting. The tool can be applied at both issuer level and asset level.

The green bond market has, so far, been predominantly focussed on expected impacts associated with financed activities (e.g. tonnes of CO₂ emissions avoided in financing a wind farm versus business as usual). However, in order to address climate risks effectively, we also need to ask: what is the risk posed if the invested wind farm does not generate the expected impact, given the changing climate conditions and the risk of extreme weather events? For example, recent storm and hurricane events debilitated a number of solar parks in the US and Caribbean. Phrased differently, how resilient are our transition efforts?

Assessing physical risk exposure from climate-related events

Climate risks can impact an entity's financial returns through acute and long-term systemic disruptions to operations, with varying degrees across sectors and geographies. As a result, it is of increasing importance that financial institutions and companies identify, assess and disclose the risk profile of their investment or business activities, an issue highlighted in the TCFD recommendations. Forward-looking climate-related risk assessments, such as those provided by South Pole's climate risk tool, enable investors and relevant stakeholders to assess the risk profile of their investments and make informed decisions.

In addition to understanding and reporting on the exposure to physical risks of their operations or assets, it is also vital that financial institutions and companies adapt their investment strategies to enable their businesses to meet these risks. Assessing the adaptive capacity of financial institutions—that is, the capacity of these institutions to adjust their investments *in response to actual or expected climatic stimuli or effects, which moderates, harms or exploits beneficial opportunities* (IPCC, 2001)—is essential in understanding the overall context and risk profile of an entity and its investments.

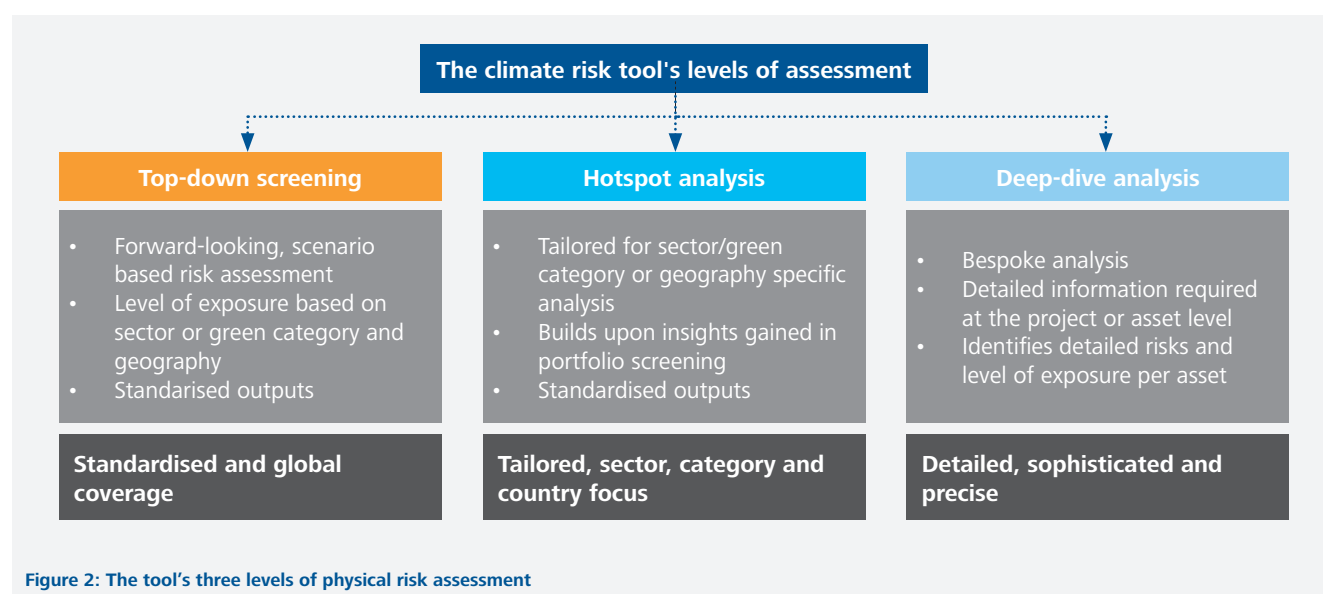
South Pole's forward-looking climate risk assessment tool

In response to the TCFD recommendations, South Pole developed a climate risk screening tool that combines a wealth of climate change expertise and investment impact analysis with the application of state-of-the-art climate models. The tool builds on a unique approach, measuring an issuer's exposure to physical climate risk based on industry context, geographical region and asset class.

The tool's top-down screening scales global climate change impacts at an asset, company or entity level. This is carried out by applying the concept of global damage functions, developed by climate economists, to estimate the overall impact of climate change on the global economy.¹ The result is a score that provides a strong indicator of potential future threats to a company or

entity's ability to produce goods or services, create value and generate revenue, as a result of the physical impacts of climate change. For example, a solar PV plant could have its infrastructure negatively impacted by climate events and experience a reduction in energy generation, lowering clean energy output (and the underlying benefits to this) and the operator/owner's revenue.

South Pole's climate risk assessment tool measures physical **risk as a change in output of x%**, referred to as South Pole's risk score.² This risk score represents the potential impact of climate change events on an entity or their investments, such as projects, and can be interpreted in the following way: **a risk score of -50% equates to a negative impact on output of 50%.**



¹ South Pole's methodology adopts the latest damage function published by Stern and Dietz in 2014.

² South Pole uses the term "output" to refer to the quantity of goods and services produced by a company or entity that in turn generate revenue for said company or entity. South Pole's risk score therefore assesses the level of impact that climate related events could have on the activities that generate a company or entity's output, such as energy generation, agriculture, hardware manufacturing, etc.

South Pole's climate risk assessment tool provides investors with a multi-layered visualisation of risk through the levels of assessment detailed in Figure 2.

1. **A "top-down" screening** provides a comparison of the physical risk exposure for different industrial sectors or green categories, as well as highlighting trends in terms of physical risks across industries, technologies and geographies.
2. **A hotspot analysis** provides an analysis that looks beyond impact on economic output and, instead, assesses the

change in intensity of specific climate risks on particular assets, projects and green technologies. This can be carried out on an issuer's core assets or the projects financed through the green bond framework.

3. **A deep-dive analysis** is the most granular and bespoke version of climate risk assessment, requiring highly detailed information for each project, as well as company or issuer engagement, in order to identify not only the relevant risks to their activities, but time frames and levels of exposure.

Green bonds: risk and adaptive capacity of impact investments

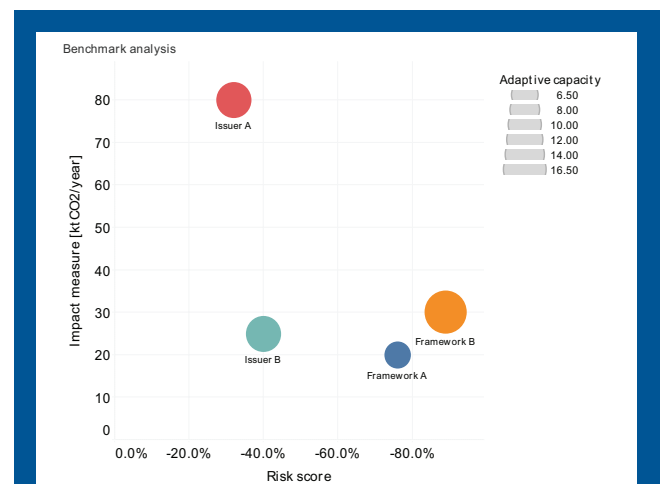
As an integral instrument in green finance (Ehlers and Packer, 2017), green bonds have extensive reporting frameworks developed, which focus on proceeds allocation impact reporting. This includes providing investors with quantitative impact indicators, such as avoided emissions and energy saved. The impacts reported, however, require investments to perform to expected capacity across their lifetime, so it is prudent that they be hedged against any potential risk resulting from climate-related events.

However, limited work has been carried out to assess the exposure of green bond issuers or their projects to climate related risks. While generally seen as more resilient, green assets can be just as exposed to climate-related physical risks as non-green assets. Current reporting educates investors about the positive impact of green bond projects, but they provide little information on whether these projects are exposed to climate risks. And, if they are, can they adapt to ensure resilience?

Assessing an issuer's overall exposure to physical risks beyond its green bond framework is a useful practice for a number of reasons. Forward-looking risk assessments analyse the exposure of the issuer based on its activities. As a result, it can illustrate the issuer's overall exposure per industry, geography and per asset (where relevant). Since the green bond market extends to emerging markets—many of which face more climate vulnerability and less adaptive capacity than advanced economies—and a greater number of issuers with lower credit ratings join the market, assessing the exposure to climate-related risks that could affect revenue generation becomes vital from both a climate risk and a credit perspective. Analysing the issuer's risk profile also provides environmentally focussed investors with an insight into their overall alignment to a low carbon and climate resilient future.

Furthermore, this data can prove very useful to issuers looking to highlight their brown to green transition—it may also enable comparison of the physical risk profile of a green bond framework and issuer with those of its peers.

Overall, assessing an issuer and their framework's climate-related risk, and underlying risk management strategies/practices, provides increasingly important information for both investor and issuer consideration.



Comparative benchmarking

Assessing the overall risk profile of an issuer provides an important tool that not only enhances the information available to investors with a sustainability focus, but also provides greater understanding of the comparison between risk vs. impact assessments for green investments. This enables issuers to benchmark certain projects or issuers against others given their risk vs. impact profile.

Screening physical risk and adaptive capacity

In collaboration with AIM, South Pole has applied the climate risk tool's capabilities to identify the level of exposure to physical risks for a sample of green bond frameworks and their underlying projects. South Pole has also developed criteria and method for ascertaining whether adaptive measures are planned or have been adopted to reduce the exposure to and potential impacts of these risks. Reviewing and providing feedback throughout, AIM was instrumental in refining the tool's application to green bond framework and issuer assessments.

The adaptive capacity screening is carried out in conjunction with the data collection process that forms part of the climate risk tool's physical risk assessment. As a result, South Pole is able to examine both reporting and project documents to extract information relevant to risk, adaptation and resilience.

The screening assesses the following:

- 1. physical climate risk identification and assessment:** have the risks applicable to the projects been identified? Has the level of exposure to these been assessed? If so, these should be highlighted by reporting publicly on the level of understanding and/or progress made.

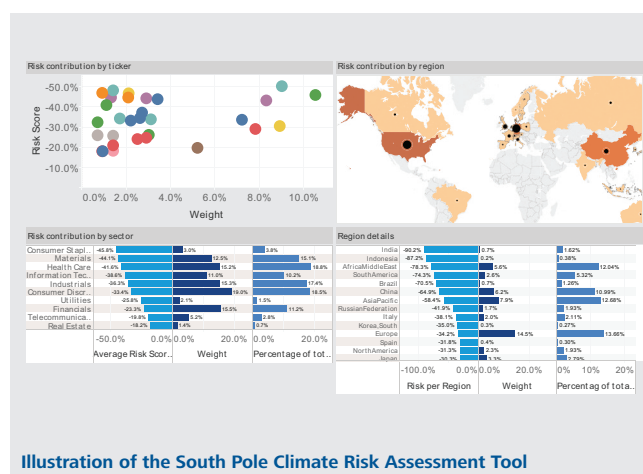
- 2. demonstrated adaptive capacity:** given the level of understanding of risk exposure, have adaptive measures been developed/implemented? South Pole provides a score to indicate the current level of demonstrated capacity by an issuer—this is the capability of the financed project to adapt to, and limit, the physical risks from climate-related events to which they may be exposed.

The above evaluates an issuer's awareness and reporting of risk and vulnerability, which could negatively impact an asset's ability to deliver its benefits—for example, due to partial or complete damage of equipment and infrastructure. Furthermore, this enables an investor to understand how the issuer, or project developer, has formulated and/or implemented adaptive measures to ensure the performance of green assets.

Physical risk assessment – an engagement tool for investors

It is important to note that the findings from the assessment are largely forward-looking, constrained by climate modelling variations and availability of data from issuers. For instance, an issuer may not publicly disclose its adaptive measures due to concerns about highlighting climate risks, but could have contingency procedures in place nonetheless. It should, therefore, be underlined that the physical risk assessment tool—like much TCFD analysis—is best used as an engagement tool between issuer and investor to discuss the findings. This should include reviewing the accuracy of the data and also encouraging dialogue between issuer and investor, in order to raise the profile, and highlight the importance, of climate risks in investment decision making. With information tools such as South Pole's, investors are empowered to have constructive and technical dialogue with issuers.

AIM strongly believes that establishing dialogue with companies/issuers is essential to being an active owner of bonds. While active ownership and engagement are typically associated with equity investors, bondholders—as providers of debt funding



to companies or other issuers—are also able to exert some influence. AIM is one such example, using its position in the market to advocate fair, responsible and sustainable business practices.

Application and results of the physical risk assessment

Top-down screening

To illustrate the use of a forward-looking risk assessment on an issuer and their green bond framework, South Pole applied the analysis and adaptive capacity screening criteria to frameworks selected by AIM, which had already been subject to internal sustainability verification.

In this case study, we present an example of a green bond framework. Under consideration is an undisclosed corporate issuer whose core business activities are within the utilities sector. Table 1 presents the results of the various levels of physical risk analysis carried out across three temperature change scenarios. As noted earlier in the case study, South Pole's risk score measures risk as a change in output of x%.

Overall, the physical risks are similar (+/- 5%) for the issuer's overall risk and the green bond framework. In this example, the green bond framework illustrates a slightly higher risk due to physical climate change impacts for the geographical location of the framework's projects. The geographical distribution for all three assessments is illustrated in Figures 3-5. In comparison to the issuer's overall risk (Figure 3) and risk profile of its energy generation assets (Figure 4), the green bond framework has a stronger focus on the Americas, whereas the issuer itself has a high percentage of operations in Europe. It is worth noting that the strong increase in the risk score for a 4°C world highlights the non-linear effects of climate change impacts. The values for all three assessments represent a medium risk similar to a global average of -50%.

Focus of top-down screening	Risk	South Pole risk score		
		2°C	3°C	4°C
Issuer's overall risk profile	Issuer's overall risk based on its core business activities and the geographic distribution of annual revenue	-2%	-13%	-46%
Risk profile of issuer's energy generation assets	Overall risk assessed for the issuer's generation facilities (Generation segment)	-2%	-15%	-48%
Risk profile of issuer's green bond framework	Assessed for projects financed by the green bond use of proceeds	-2%	-18%	-53%

Table 1: Three levels of analysis carried out to assess issuer's level of exposure to physical climate risks.

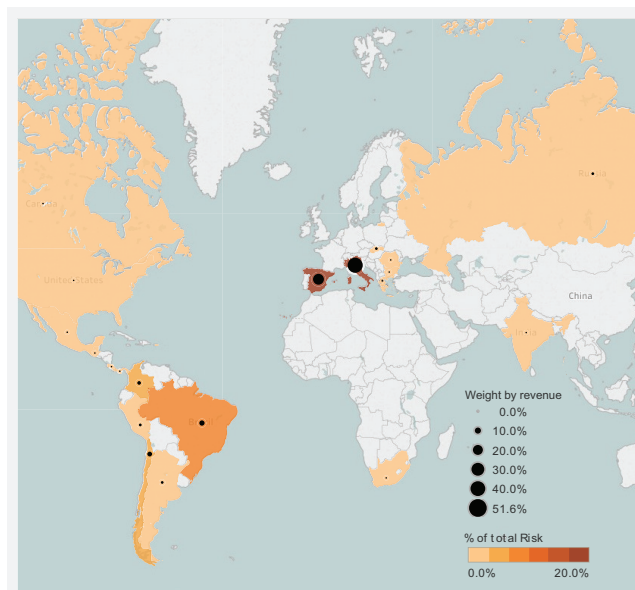


Figure 3: Distribution of issuer's overall risk (shading) given the share of revenue generation per geography for a 2°C world (Data for 2017). Black dots represent the weight of the country based on its contribution to revenue.

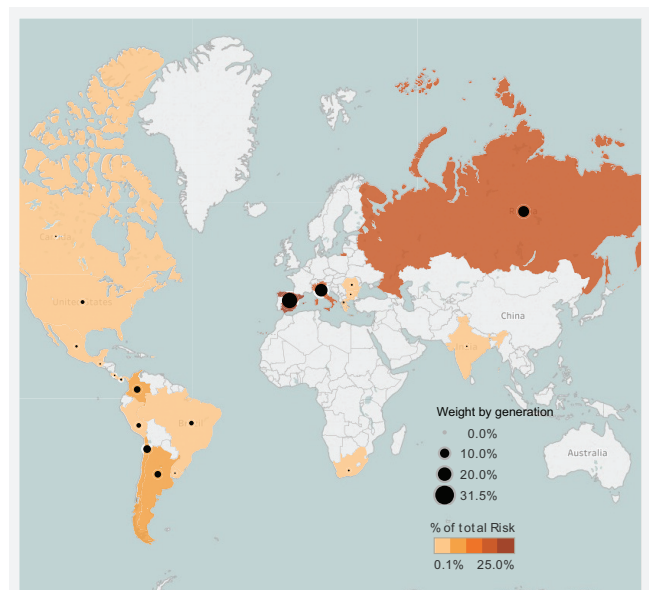


Figure 4: Distribution of physical risk (shading) for issuer's energy generation assets given the share of overall generation per geography for a 2°C world (Data for 2017). Black dots represent the weight of the country based on its contribution to energy generation.

Figure 3 provides an illustration of the geographic distribution of the issuer's overall risk exposure for the markets it operates in. The darker the shade of orange per country, the greater the level of risk exposure. Risk exposure is significantly affected by the share of overall revenue per country, indicated by the size of the bubbles.³

Taking into account that close to 35% of the issuer's revenue results from energy generation activities, assessing the level of exposure to physical risks for its energy generation facilities is critical. Figure 4 shows the geographic distribution of risk for the issuer's production sites, with the share of overall generation per geography represented by the bubble size.

Figure 5 illustrates the assessment of the issuer's green bond framework. The colour scale indicates the contribution of the project locations to the overall risk and the size of the bubble the share of the use of proceeds per geography. Overall, the projects have a stronger focus on the United States and South America, with a significant share of use of proceeds in Brazil and Peru, contributing to an increase in the overall risk of the framework, compared to that of the issuer—see Table 1.

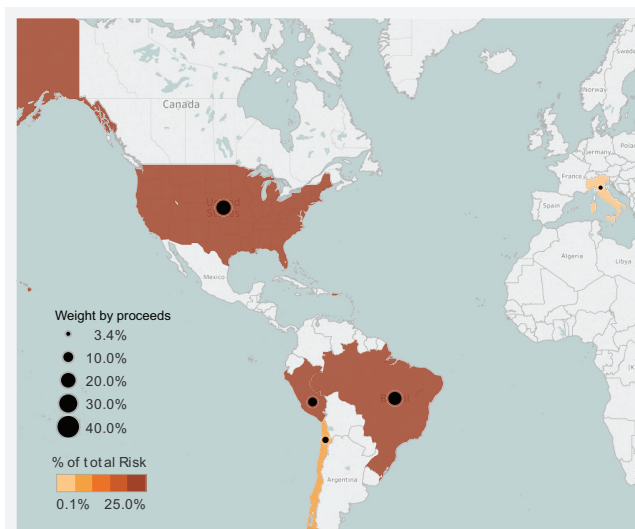


Figure 5: Distribution of physical risk (shading) for projects in the issuer's green bond framework given the share of overall use of proceeds per geography for a 2°C world (Data for 2017). Black dots represent the weight of the country based on its contribution to overall proceeds.

Framework and issuer

Green bond investors are not only exposed to the green bond framework, but often also to the issuer's overall risk profile. The majority—approximately 90% in 2017⁴—of green bonds issued are green 'use-of-proceeds' bonds, which are earmarked to finance or refinance green projects, backed by the issuer's entire balance sheet. As a result, use-of-proceeds investors are investing in the issuer's activities as a whole and are, therefore, exposed to the same risks as they would be had they invested in the issuer's standard bonds.

While bonds may be less exposed in the short term than other financial instruments to the potential physical risks of climate change, given their average maturity of seven years, certain green assets are considered high-risk assets due to their location or type. Considering that climate-related risks can have a direct effect (Ehlers and Packer, 2017) on revenue generation assets (factories, power plants, mills, etc), the financial stability of some issuers could be heavily affected. As a result, they may be subject to an increased risk of a credit rating downgrade.

³ Data is based on publicly available information from the Issuer (annual report, etc.) and South Pole analysis.

⁴ Of the USD 178 billion in labelled green bond issuance, USD 155.5 billion had 95% of proceeds dedicated to green projects aligned with the Climate Bonds Taxonomy (CBI, 2018).

Hotspot analysis

In comparison to the top-down screening results discussed in the previous section, a hotspot analysis conducted at the issuer and green bond framework level can evaluate the change in intensity of specific risks for business segments, green technologies, geographies or individual assets. The analysis focuses on the effect of climate change on the probability and intensity of specific hazards such as heatwaves, heavy precipitation and drought. The effect of climate change is calculated by comparing current day climate conditions against future forecast conditions.⁵

This case study focuses on two specific risks⁶, outlined in Table 2. These hazards are chosen for three reasons: 1) they are very likely to have material impact on the projects (Arent et al, 2014); 2) data quality and coverage are high (Sillmann et al, 2013-a; Sillmann,

2013-b); and 3) the hazards are well simulated by the underlying global climate models (Sillmann et al 2013-a; Sillmann, 2013-b).

Projections of the effects of climate change have to deal with different sources of uncertainty (Knutti et al, 2008). One example is the uncertain development of future greenhouse gas concentrations. To address this variable, a scenario approach is taken. The first represents a strong mitigation scenario, limiting global climate change to 2°C, and the second a business as usual scenario where global temperature will increase by 4°C or more. Another cause of uncertainty is in the climate models themselves and, to address this challenge, we examine not just a single model, but an ensemble of models.⁷ The spread of these ensembles is used to assess the robustness of the simulated changes.

Risk	Indicator from ETCCDI	Description
Heavy precipitation	Monthly maximum consecutive 5-day precipitation (Rx5day).	A change in prolonged precipitation events can be used as an indicator for changes in flooding and connected hazards like landslides etc. leading to supply chain interruptions, transport difficulties, damage to facilities.
Drought	Maximum length of dry spell, maximum number of consecutive days with daily precipitation less than 1mm (CDD)	Indicator for inadequate water supply leading to increased operating costs, production interruptions etc.

Table 2: Indicators for heavy precipitation and drought as defined by the ETCCDI

An investor can use two different methods to assess the significance of the respective changes, given the inherent uncertainty of the models, based on their value judgment and risk perception. In a balanced approach, the median signal of the ensembles is used. The median is the value where 50% of the models in the ensemble project a stronger change and 50% a weaker change. This is therefore a balanced measure of risk. An alternative approach, tilted towards a 'stress test', could be carried out using the 75th percentile to assess the more extreme values of the ensemble.

Figure 6 illustrates a hotspot analysis employing a balanced (median) approach to assess the issuer's hydropower generation assets in Italy, which account for a considerable proportion of its generation activities. Figure 7 illustrates a hotspot analysis employing a stress testing approach to assess the risk profile of the solar PV projects financed by the green bond's use of proceeds.

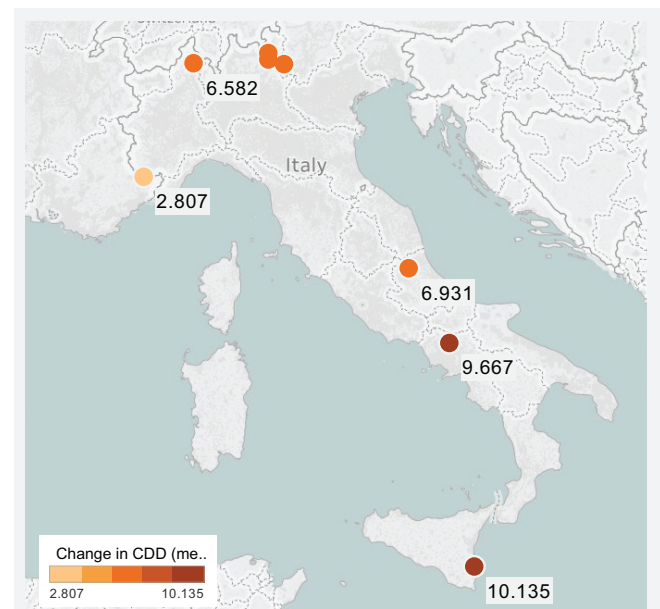


Figure 6: Relative change [%] in drought intensity (CDD) for the issuer's Italian hydropower facilities in operation. Assessment is carried out for a 20 year period centred around 2040 and a 2°C scenario (Issuer data for 2017).

⁵ In this case study we compare a twenty-year period centred around 2040 (2031-2050) against 1995 (1986-2005). Indicators are averaged over these two time periods to filter out natural variability.

⁶ The respective indicators used to measure these risks, were defined by the Expert Team on Climate Change Detection and Indices (ETCCDI).

⁷ The ensemble is a subset of the climate models included in the Coupled Model Intercomparison Project 5 (CMIP5) a full list of the models used is available at <http://climate-modelling.canada.ca/climatemodeldata/climindex/index.shtml>

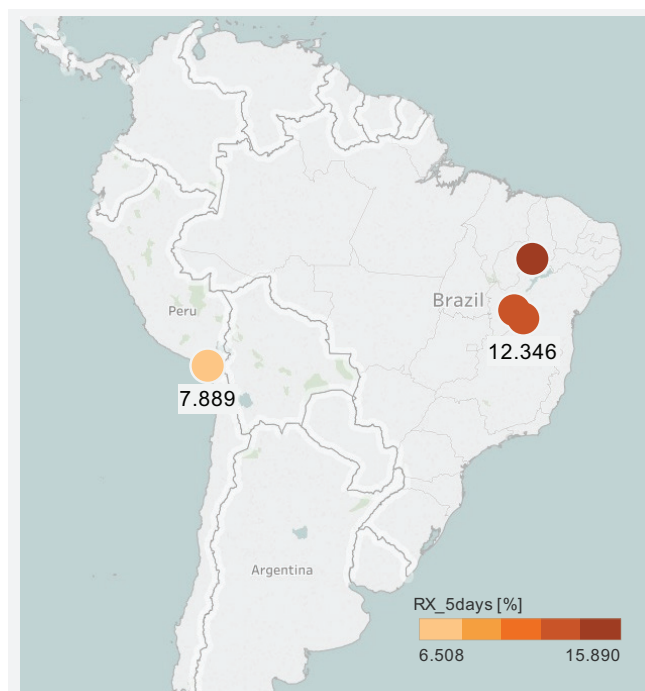


Figure 7: Change in heavy precipitation intensity (Rx5day) for solar PV facilities in Brazil financed by green bond use of proceeds. Assessment is carried out for a twenty-year period centred around 2040 and a 2°C scenario (issuer data for 2017).

Issuer's physical electricity generation assets

It is important to understand the correct context for different types of facilities when conducting a hotspot analysis. For example, hydroelectric power facilities can be heavily impacted by extensive periods of drought which, combined with high temperatures, can result in low water reserves.

In 2017, hydropower generation in Spain and Portugal—where the issuer's installed capacity represents roughly 8% of overall generation—was severely affected, with national hydropower generation decreasing by 50% and 47%, respectively (ICIS, 2018). During the same period, Italy experienced a historic drought—a decrease in rainfall of 36% below average (World Meteorological Organization, 2017) resulted in its driest January-September on record and a state of emergency was declared in several regions. Although no conclusive generation data was available for the issuer's hydroelectric plants illustrated in Figure 6, it is clear that future increases in the intensity and duration of droughts could have negative consequences for hydropower generation in the region. The issuer's installed hydropower capacity in Europe accounts for approximately 60% of total installed generation capacity in the region, and close to 20% of overall generation output. Figure 6 illustrates the level of exposure to extensive drought for eight hydroelectric stations, representing approximately 50% of the installed capacity in the country.

Given the possible impacts highlighted above, it is important to identify the facilities which are heavily exposed to each respective risk and present robust climate change projections. The potential rate of increase in risk can then be further assessed. We can use the spread of the ensemble to assess the former and a balanced approach looking at the median to address the latter. For the Italian facilities illustrated in Figure 6, the change in the maximum number of cumulative days without rain is around 10%. While a median increase in intensity of 10% may seem small, given the already dry conditions in this area, a further increase in the maximum number of cumulative days without rain would have a significant impact. Furthermore, change is noticeably stronger in the south than in the north of the country. Here, the climate change signal is robust, showing an increase also for the lower percentiles. The intensity changes vary from 3-4% for the 25th percentile up to 15-16% for the 75th percentile.

Forward-looking assessments that can model and illustrate various degrees of exposure for an issuer can therefore be vital for decision making in their medium- to long-term climate change strategies. They are also particularly useful for issuers and investors in industries where asset generation or production represents a significant portion of revenue, and can serve as a powerful information tool for engagement.

In recent years, there have been increasing concerns about the resilience of renewable energy infrastructure to weather events (Ivanova, 2018). However, without an accurate understanding of, and planning for, exposure to climate events, renewable energy infrastructure can be similarly vulnerable to climate-related hazards as conventional energy generation infrastructure. Figure 7 shows the locations and risk profile of an issuer's solar PV projects experiencing heavy precipitation events in 22 years (2040). In this example, we consider a stress testing approach, looking at the 75th percentile for which an increase of 13% in the intensity of these events is projected for a number of projects in Brazil. Given the average solar PV lifespan of 25 years, details on the project's capacity to adapt to these increases in intensity are essential to understanding the overall risk profile of the asset and its ability to operate at capacity.

The negative impacts of extreme climate events on infrastructure that has not been designed to withstand such activity can be severe. In 2017, Hurricane Maria devastated ground-mounted PV infrastructure in Puerto Rico, while roof-mounted infrastructure fared much better (Hotchkiss, 2018). Geographic location and climate resilient design have been the predominant factors in the fate of the different solar PV assets on the island, highlighting the importance of ensuring that infrastructure is designed to meet the risks to which the asset is most exposed and vulnerable.

Project-level impact reporting					South Pole Risk Score			Demonstrated adaptive capacity
Green bond projects per type of issuer framework and project technology	Location	% of framework use of proceeds	Approx. annual Electricity Production (GWh/year)	Approx. annual avoided emissions (tCO ₂ /year)	2°	3°	4°	Score (1-20, 20 = Max)
Wind energy								
Corporate	United States	9.1%	1,200	800,000	-1.51%	-8.03%	-32.31%	11.5
Corporate	Chile	4.5%	300	250,000	-1.70%	-10.50%	-40.69%	11.5
Multilateral Development Bank Supranational	India	1.4%	750	300,000	-8.35%	-55.75%	-89.65%	16.5
Solar energy								
Corporate	Brazil	2.3%	220	110,000	-2.96%	-24.39%	-67.94%	11.5
Corporate	Peru	4.5%	450	200,000	-3.88%	-32.17%	-76.06%	6.5
Other renewable energy								
Corporate	Italy	0.5%	5	2,000	-1.80%	-11.83%	-44.56%	11.5

Table 3: Example of a forward-looking analysis applied to the corporate issuer under discussion providing South Pole's physical risk and adaptive capacity scores. Together, these metrics allow investors to assess a framework or project's impact profile given location and technology, against its risk profile, while considering its capacity to adapt to these risks. A project from a multilateral development bank issuer is also included for comparison.

Adaptive capacity

Table 3 outlines the relevant impact metrics and physical risk scores associated with a selected list of projects financed by the green bond, following a framework-level screening. In addition, South Pole has applied its adaptive capacity criteria to the green bond framework.

The various elements of reporting that currently define best practice are shown in Table 3, along with the elements of a forward-looking risk analysis: a risk score and an adaptive capacity score. This multidimensional analysis of green bonds provides insight into the use of proceeds' expected impact, as well as the strategies in place to ensure impact objectives are met, given exposure to climate-related risks.⁸

As previously highlighted, the issuer has a number of solar PV projects in Brazil with considerable exposure to heavy precipitation. A physical risk screening illustrates the risk profiles of the projects given a change in temperature of 2°C, 3°C and 4°C (shown in Table 3 in dark orange). The degree of negative impact on the asset's ability to operate to capacity ranges from 3% in a 2°C world, to 68% in a 4°C world.

Since the risk profile alters significantly between 2°C and 3°C, assessing the project's capacity to adapt across the range of risks is vital. South Pole's adaptive capacity criteria was applied to the corporate issuer's projects, but the scoring was limited to framework-level information. As a result, it was not possible to assess whether the Brazilian projects and the relevant technology financed had project-specific strategies in place to enable it to adapt to the geographic risks estimated by the models.

The issuer provides information at the company level on its environmental management system (EMS), applied across all of its energy generation projects. Information on the EMS, combined with three-month weather forecasts, ensure projects are adapted to withstand short-term weather events. Given that the issuer's green bond framework is composed entirely of renewable energy generation technologies, most of the projects in the framework are awarded the same score (11.5), which gives an indication of the issuer's general risk and environmental assessments, adherence to international environmental management standards and its level of technology reporting.

⁸ It is important to note that the adaptive capacity score should be considered conditional to the physical risk score. For example, projects and/or issuers with low adaptive capacity scores but low risks scores under warming scenarios may not be a concern.

One of the issuer's projects, for which information is available publicly, was given a score of 6.5. Project documents did not detail any assessments disclosed by the issuer, creating difficulty in determining the accuracy and relevance of information. With the scoring carried out using only the information provided at the project level, the results were considered inconclusive. The considerable high risk in warmer global scenarios combined with a low adaptive capacity score would prompt engagement by a green bond investor, such as AIM, to discuss the project with the issuer. The concern about limited adaptive capacity combined with high physical risk scores may be discrete (project specific) or systemic.

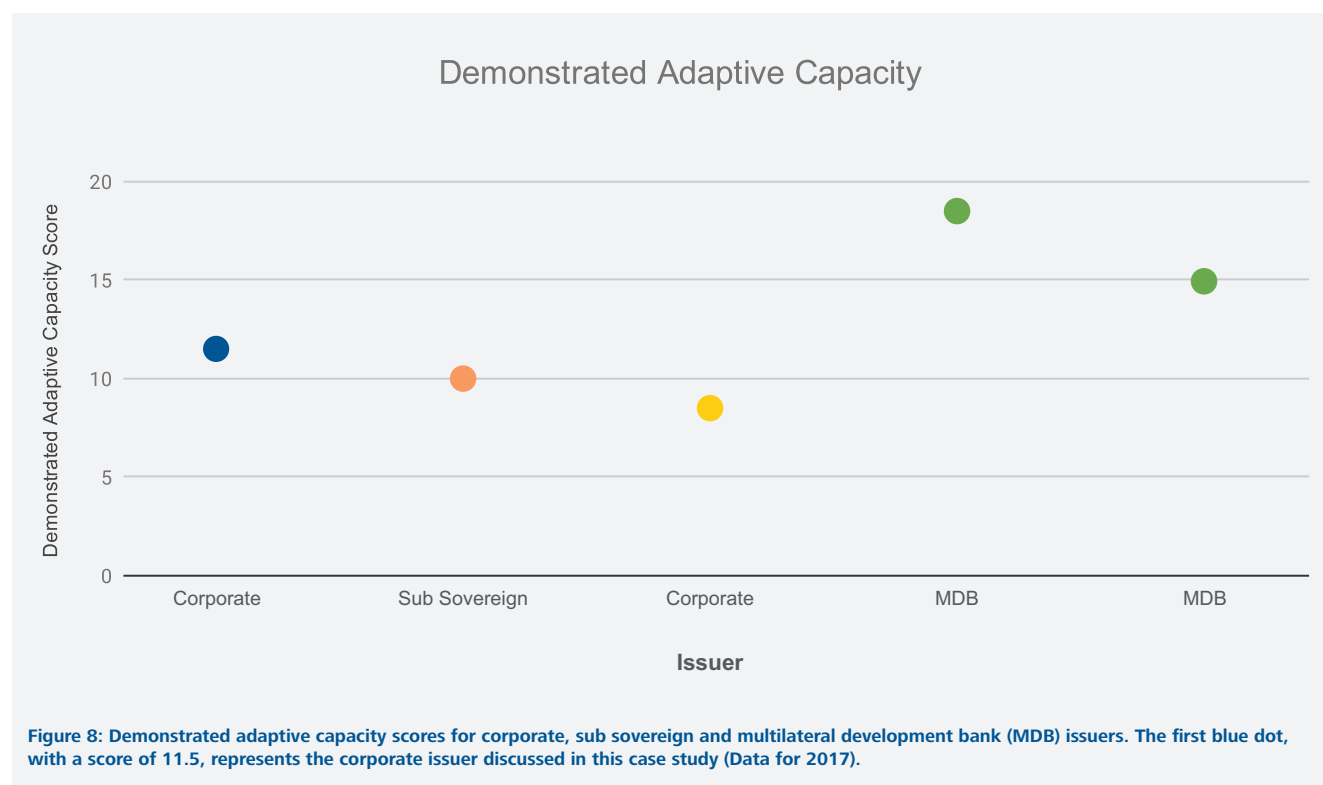
It is important to note that risk and adaptive capacity scores are designed to inform an investment strategy and should, therefore, be assessed within the context of the project's location and relevant impact metrics. Projects in some geographies will inevitably deliver high risk scores when analysed against certain climate scenarios, yet their impact and necessity in the region can be far greater than those of projects with similar costs and characteristics in other locations.

An MDB wind project in India provides a good example—see Table 3. It is estimated to have a potential for avoided emissions of 2,500t CO₂/year per US\$1m of investment in the project. In comparison, the US-based wind project is estimated to have a

potential for avoided emissions of 1,900t CO₂/year per US\$1m of investment in the project.

Another important metric for comparison, although not disclosed in either issuer's reporting, would be the number of households provided with clean energy. Given the project's location in India and the annual estimated generation for the project, the number of households provided with clean energy would be substantially higher than in the US. While the risk profiles of the two projects in the comparison differ greatly, the project documentation for the MDB wind project reveals significant measures taken to design and operate a project that is fully resilient against climate risks.

In order to test the robustness of its adaptive capacity screening criteria and illustrate the range of adaptive capacity scores across issuer types, South Pole applied the criteria to a variety of green bond issuers in which AIM has invested, providing an evaluation of their frameworks—see Figure 8. The results are aligned with those in Table 3, with corporate issuers scoring significantly lower than an MDB issuer. This is largely due to the variety of risk identification and impact assessments that projects financed by a development bank undergo, coupled with detailed project-level reporting revealing risk management strategies. In particular, MDB reporting is generally more extensive and detailed than that of other issuers, enabling the MDB to demonstrate more comprehensive risk identification and management protocols in comparison to other issuers.



Conclusions and key takeaways

This case study is a collaboration between AIM and South Pole – both pioneers in the green bond market – to assess green bond investments in terms of physical risk exposure and their risk management plans. The need for forward-looking climate risk assessments has been well articulated in TCFD guidelines, however the focus of climate risk assessment tools has largely been on transition risk and remains relatively underexplored in the green bond market.

Physical risk assessment can be applied, using the South Pole tool, to green bond frameworks, green bond issuers and to issuers of general purpose bonds. This enables comparisons between all three, including enabling comparison between the green bond market and wider fixed income market.

In recent years, the green bond market has experienced rapid growth assisted by detailed frameworks for impact reporting to highlight the benefits of the use of proceeds. However, as more rapid growth and market expansion is required to meet the US\$1 trillion by 2020 target to boost progress on the ‘implementation of country climate plans’ (CBI, 2018), **the market can use forward-looking risk assessments to advocate the resilience of green bonds as an investment strategy and identify risks and opportunities related to climate resilience.**

Identifying and reporting on operations’ or assets’ exposure to physical climate risks should be coupled with an action plan to adapt strategies or investments that will enable businesses to manage these risks. The findings from this case study highlight a low level of disclosure from green bond issuers with regard to either forward-looking assessments or climate-related risk identification. In addition, very few issuers are currently reporting on adaptive measures or strategies for their use of proceeds. **AIM and South Pole urge green bond issuers to improve disclosure on physical risks and their adaptation strategies.**

Although a handful of issuers, mostly MDBs, already undertake physical risk assessments, there is little evidence or demonstrated reporting. **Improving reporting to include climate-related risk assessments, and the adaptive capacity of projects, would be of immense benefit to issuers and investors alike.**

Assessing not only the green bond framework and assets, but also the issuer’s risk profile, provides environmentally focussed investors with an assessment of an issuer’s

alignment to a low carbon and climate resilient future. For example, a green bond framework may present low physical risks, but the issuer as a whole may be considered highly vulnerable as a result of global warming. As green bonds typically carry the overall credit risk of the issuer, potential impacts of physical risks on the issuer’s overall performance must be evaluated.

Assessing the risk profile of an issuer’s framework provides investors with a comparison between a green project’s risk exposure and its positive impact. Such information enables investors to assess whether to invest in assets with high vulnerability, but strong positive climate impact due to their geographic location, or in assets deemed to be low risk, but with a lower positive contribution to climate change.

It is expected that forward-looking, climate-related risk assessments will increasingly be implemented by both financial institutions and corporates. **In addition to measuring the positive impact of green assets, investors should be aware of projects’ exposure to climate risks and whether they have the ability to adapt to these risks and ensure resilience.**

Through a combination of impact reporting and assessments that identify and adapt projects to the physical risks of climate-related events, **green bond issuers can increase flows not only to their projects, but also across a greater diversity of projects within the green categories.** This would ensure that green bond issuers are at the forefront of disclosure best practice.

The green bond market remains largely focussed on climate change mitigation, with adaptation measures very much underrepresented. Both strategies are considered critical in a sustainable, low carbon and climate resilient global economy. **Physical risk modelling and data tools, such as South Pole’s climate risk tool, empower investors to raise the profile of climate resilience in the market and enable deeper engagement between issuer and investor on the topic.**

The authors acknowledge that the tool is limited by availability of data from issuers. **The development of South Pole’s climate risk tool is intended to encourage greater disclosure on climate risks and adaptive capacities of green bond issuers, at both the framework and issuer level.**

About the authors



Affirmative Investment Management (AIM), a dedicated impact bond asset manager, has been instrumental in developing the impact bond market. AIM offers several impact and climate bond strategies to its clients, all with detailed impact reporting. We have been proactive in the development of impact measurement tools for green bonds—including co-developing the publicly available 'Carbon Yield methodology', funded by The Rockefeller Foundation, to capture the greenhouse gas emissions avoided of green bonds. We are excited to partner with South Pole—leading climate data and solution providers—to review and test their climate risk assessment tool, the results of which are summarised in this case study.

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South Pole, a leading provider of global sustainability financing solutions and services, has developed a climate risk assessment tool allowing investors and asset managers to assess climate risks across entire portfolios, covering all sectors and geographies. By fully integrating physical and transition risks and opportunities into long-term asset allocation, the tool provides valuable inputs for reporting, stakeholder dialogue, and informed decision-making. The use of smart algorithms and global climate databases allows the tool to provide aggregated climate risk scores, which help investors to identify risks and opportunities in their portfolio in alignment with TCFD recommendations.



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Readers can also listen to Nico explain the tool and show its functionalities by scanning the QR Code or clicking [here](#).

Physical risk and adaptive capacity screening methodology

Figure 9 below illustrates the process carried out by South Pole to conduct the physical risk screening⁹.

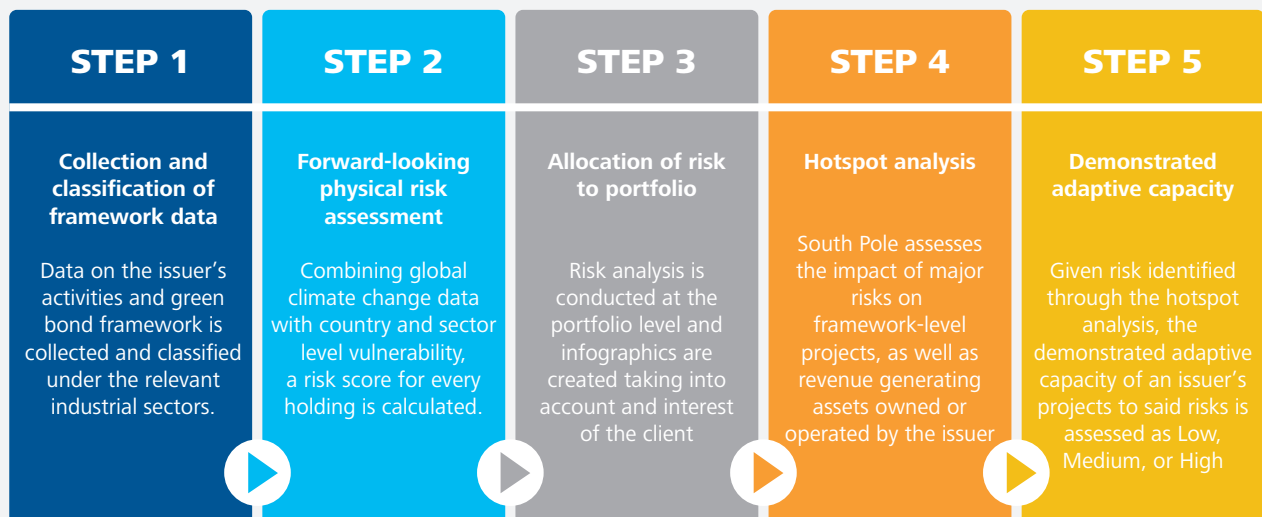


Figure 9: South Pole physical risk assessment process for green bond issuers and frameworks.

Collection and classification of issuer and green bond framework data: as a first step, South Pole collects all relevant data for an issuer's revenue generating activities, as well as data for its green bond framework. We then apply an in-house mapping function to assign a specific industrial sector to the issuer's core business activities and all green bond projects according to their relevant green category.

Identification of the issuer's context: the issuer's key economic parameters, including revenue or production capacity, are analysed and mapped according to their geographical distribution, outlining risk distribution given the key areas of revenue generation for the issuer.

Forward-looking physical risk assessment: global climate temperature projections are extracted from the global climate model ensemble, Coupled Model Intercomparison Project Phase 5 (CMIP5), which includes 15 global climate models, and linked to a global vulnerability database developed by South Pole, constructed to address every country and industrial sector, specifically.

Allocation of risk to the framework's projects: a risk analysis is performed for both the issuer's overall activities and its green bond framework, using state-of-the-art data analysis tools. Infographics and physical climate risk maps are generated to show, for example, the geographical distribution of the framework's risk.

Project-level hotspot analysis: South Pole maps the exact location of the issuer's green projects and assesses the impacts of major risks on these for a given point in the future, such as 2040. These can include heavy precipitation, drought and heat waves. Data is sourced from the CMIP5 global climate model used by the IPCC.

Demonstrated adaptive capacity: given the risk indicators resulting from the hotspot analysis, South Pole assesses the demonstrated adaptive capacity of an issuer's projects or framework by evaluating the issuer's green bond reporting and other public disclosure information. This identifies climate-related risks, as well as any measures taken in the management of and adaptation to these. The levels of demonstrated adaptive capacity are divided into the following categories:

- Projects scored Low, Medium or High in terms of adaptive capacity demonstrated;
- Projects will not be scored where insufficient information is available to make a judgement on the adaptive capacity.

⁹ For a detailed methodology document or further information, please contact h.vartto@southpole.com

Evaluating the adaptive capacity of an issuer's project portfolio: South Pole assesses the adaptive capacity based on the documents disclosed by the issuer through either its green bond reporting or its company-level reporting, looking for evidence that the issuer carries out particular climate-related risk assessments, or vulnerability assessments, as well as adherence to international environmental or risk management standards.

The evaluation is carried out through scoring criteria developed by South Pole to assess and score the demonstrated adaptive capacity of an issuer's projects across the following key areas:

- **An issuer's identification and assessment of the relevant climate-related risks** that its proceeds finance, distinguishing between geographic location and green bond category (technology), where relevant.
- **The development and implementation of risk management (adaptation) strategies** based on the identified risks, highlighting the capacity of the at-risk technologies or projects to adapt to the relevant risks identified.
- **The issuer's level of reporting on its adaptive capacity strategies**, placing attention on accessibility of the relevant documents. These include documents detailing both the type of assessment carried out to identify relevant risks, and the development and implementation of adaptive measures.

- **Finally, the positive or negative responses to the criteria generate an overall score**, which is then categorised into three levels of demonstrated adaptive capacity: High, Medium or Low. The aim is for the results to serve as an indicator at the project level. However, due to data and reporting limitations of publicly disclosed documents, the scores may be provided at the framework and/or technology level.

Considering that an investor's green bond portfolio can include a variety of issuers, the criteria are applied at the level of detail possible according to the issuers' disclosure practices. The greater the level of detail made publicly available by an issuer, the higher the score received by the issuer.

As an example, pure play renewable energy issuers can apply certain risk management systems and standards across their entire framework, due to the fact that the technologies financed have similar characteristics. Adhering to one international risk management standard for all projects enables an issuer to design/operate a green asset in a way that takes climate-related risks into account without having to apply individual project-level risk management strategies. Where an issuer carries out and reports on adaptation strategies across an entire category, all projects in this category will be scored the same, unless otherwise disclosed by the issuer. If risk assessment and adaptation strategies are developed and reported for each individual project, they will be scored individually.

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