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Environmental Risks - Sovereigns

How Moody's Assesses the Physical Effects of Climate Change on Sovereign Issuers

Summary Points

» **The credit implications of physical climate change are captured in a broad set of rating factors that influence a sovereign's ability and willingness to repay its debt.**[1] Economic and social systems are exposed to climate change, with governments typically the first line of defense in dealing with the mitigation and response to such challenges. While our sovereign bond rating methodology does not account separately or explicitly for the credit risks posed by climate change, climate risks are already broadly captured in the four key risk factors we use in our analysis – economic strength, fiscal strength, institutional strength and susceptibility to event risk – either directly or indirectly through a variety of indicators.

» **The physical effects of climate change will vary depending on time frame and magnitude of impact.** *Climate trends*, such as global warming, are typically gradual, multi-decade (or multi-century) phenomena, with little visible change from one year to the next. *Climate shocks*, such as major cyclones or droughts, can have significant and one-off credit implications given their potential to disrupt economic and social activity.

» **We identify four primary channels by which the effects of physical climate change are transmitted to sovereigns' credit profiles.** These are: 1) the potential economic impact (for example, weaker activity due to a loss of agricultural production); 2) damage to infrastructure assets as a direct result of the physical destruction incurred from climate shocks; 3) rising social costs brought about, for example, by a health crisis or food security concerns; and 4) population shifts due to forced displacements resulting from climate change. We plan to address additional credit challenges facing sovereigns from the transition to a low carbon economy in a separate publication.

» **Sovereign susceptibility will depend on an issuer's exposure and resilience to climate change.** Exposure to climate change is a function of a sovereign's economic diversification and geographic location. To assess resilience, we focus on a sovereign's adaptive capacity and fiscal flexibility, as well as the country's income levels. Furthermore, the presence of government policies to mitigate climate change risks (for example, natural disaster insurance or a savings funds) can also help bolster a sovereign's resilience. In general, sovereign issuers with smaller, less diversified economies and geographies, lower incomes and quality of infrastructure, and lower fiscal flexibility are more susceptible to the credit implications of climate change.

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Governments are typically the first line of defense in dealing with the mitigation and response to climate change

Historically, stable and predictable climatic conditions have been important factors in the development of agriculture and in the location and growth of economic and population centers. Material climate change (see Appendix A) could therefore threaten the economic and social systems whose growth and success continue to depend on such stable climatic conditions.

For example, rising sea levels due to increasing global temperatures threaten countries with large coastal populations; while persistent drought and flooding are likely to disrupt economies still heavily dependent on agriculture.

Economic and social adaptation can minimize the adverse effects of climate change, but may not always be a viable option. Political leadership in many countries may lack the foresight, political will, or resources to adapt to changing conditions.

In the absence of private insurance, governments are ultimately responsible for providing support to sectors of the economy and populations affected by climate change, and often bear the cost of mitigating its effects. Such costs add to the rising burden on the government, and can represent a material credit consideration for a sovereign's credit profile.

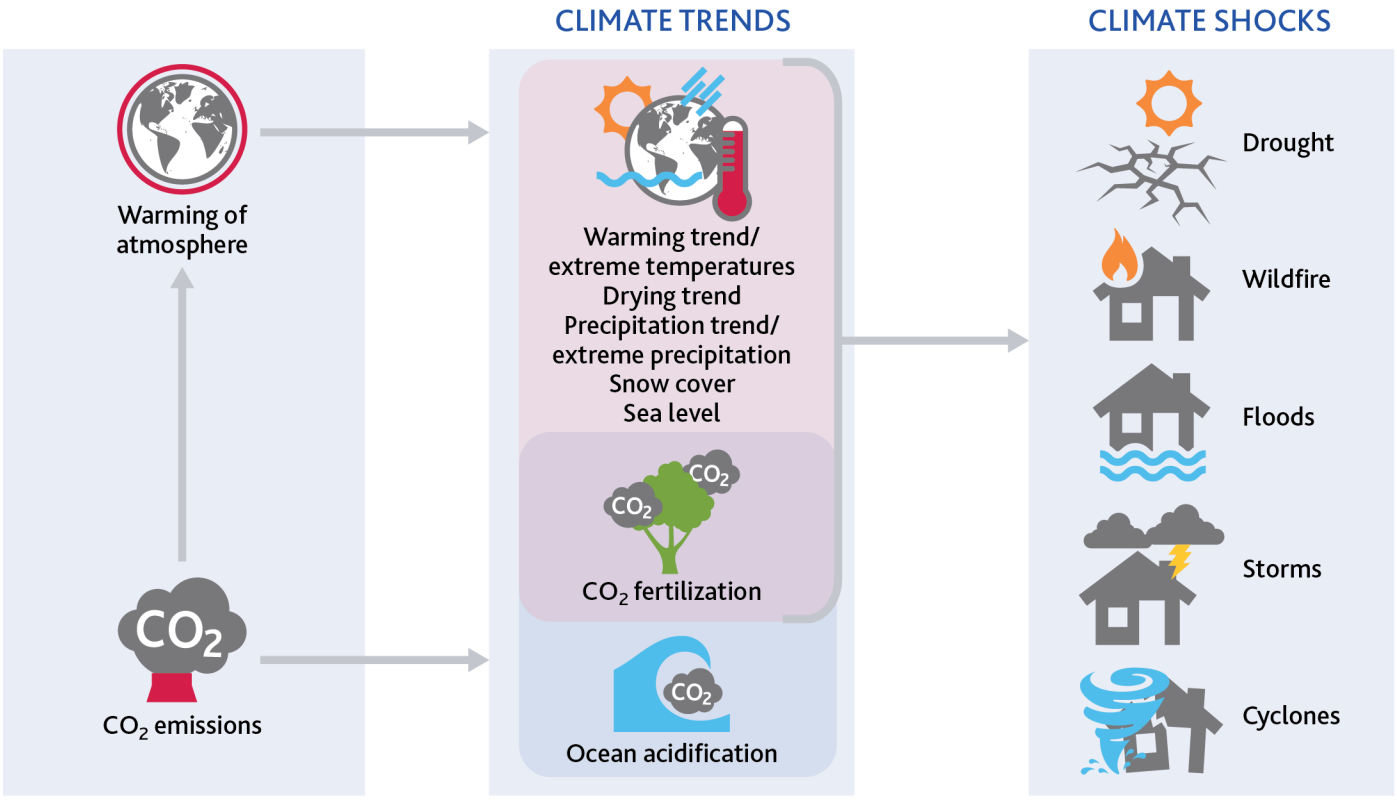
This paper sets out an illustrative, but not comprehensive, set of indicators which offer insights into the potential impact of physical climate change on sovereign credit risk and the relative susceptibility of sovereign issuers to the physical effects of climate change.

The physical effects of climate change will vary depending on time frame and magnitude of impact

While not mutually exclusive, we categorize the physical effects of climate change into two broad, related groups: climate *trends* and climate *shocks* (Exhibit 1).

Exhibit 1

We Categorize Physical Effects into Climate Trends and Climate Shocks



Sources: Moody's Investors Service, Intergovernmental Panel on Climate Change

Climate trends are gradual, multi-decade (or multi-century) phenomena, with little visible change from one year to the next. These are typically chronic in nature, and include the trend of warming, as illustrated by rising mean temperatures globally, and other changes such as a decrease in cold temperature extremes and an increase in warm temperature extremes.

Climate shocks refer to the physical events that are a direct consequence of climate change. Such shocks are typically acute and include droughts, floods, and cyclones. While the occurrence of a singular, isolated climate shock may not be the direct result of climate change, the Intergovernmental Panel on Climate Change (IPCC) notes that the probability and frequency of such shocks (e.g. damaging cyclones) will increase at higher temperatures and/or greater extremes in temperatures and precipitation.[2]

In general, climate *trends* are unlikely to have a clearly discernible credit impact given long time frames, and the ability to mitigate or adapt. However, such trends will increase the probability and frequency of irreversible change and climate shocks, meaning that they can bring about substantive changes to economic and social systems over the long term. We will reflect climate trends in our credit analysis as they materialize or to the extent they can be foreseen.

By contrast, climate *shocks* can have significant and one-off credit implications given their potential to disrupt economic activity. While the overall trend of climate *shocks* is increasing, the timing and magnitude of an individual physical event is unpredictable.

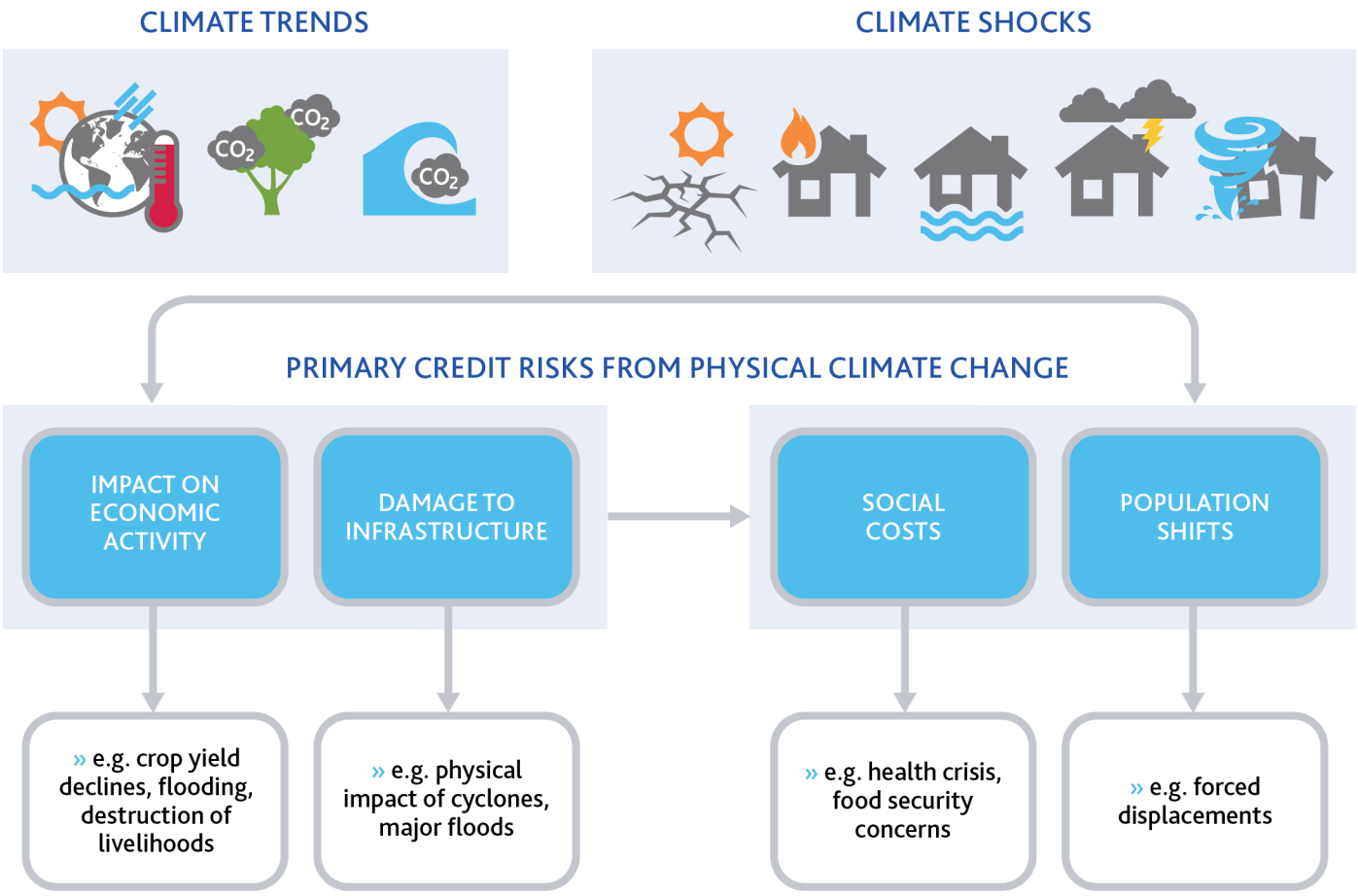
We identify four primary channels by which the effects of physical climate change are transmitted to sovereigns' credit profiles

We identify four primary transmission channels by which physical climate change can influence sovereign credit profiles (Exhibit 2). These four categories demonstrate a considerable degree of reflexivity: for instance, weaker economic activity and damage to infrastructure caused by climate trends or shocks is likely to lead to a crystallization of rising social costs and population shifts. We will aim to capture the impact of climate change transmitted through these channels in our analysis of economic, institutional and fiscal strength as they materialize over time and through our assessment of susceptibility to event risk.

Some sovereigns, in particular oil-exporting ones, will face an additional set of economic, fiscal and institutional credit challenges over the longer term related to a transition to a low carbon economy. We plan to address the credit challenges facing sovereigns from carbon transition in a separate publication.

Exhibit 2

We Identify Four Primary Transmission Channels From Physical Climate Change



Source: Moody's Investors Service

Impact on Economic Activity: Whether on a temporary or enduring basis, climate change can negatively influence the productive capacity of an economy. From a sovereign perspective, a material weakening of economic activity due to climate change will weigh on fiscal revenues and may lead to an increase in transfer payments and welfare expenditure.

Studies on the economic impact of climate change over the past 20 years vary significantly. They rely on a large number of assumptions, show considerable variations across countries and tend to focus on the economic impact of climate trends. The effects of climate shocks are idiosyncratic and generally studied on a case by case basis. These limitations notwithstanding, the IPCC finds that global temperature rises of approximately 2°C can, on average, lead to economic losses of between 0.2% and 2.0% of income.[3]

Extreme temperatures, drying and persistent droughts can significantly reduce crop yields. For instance, low rainfall and repeated droughts in recent years have stunted growth in India's (Baa3 positive) rural demand.[4] Major losses in crop production can also trigger other negative economic effects such as a spike in food price inflation.

In terms of climate trends, the gradual desertification of Israel (A1 stable), Lebanon (B2 negative), and Jordan (B1 stable) is leading to land degradation and soil infertility. According to the Lebanese authorities, economic damage from climate change could reach more than $80 billion (156% of 2015 GDP) by 2040.[5]

Climate change may generate some positive effects on economic activity in a limited group of countries. According to the Stern Review 2006 paper commissioned by the UK government, temperature increases of between 2°C and 3°C may produce net economic benefits in higher latitude countries or regions, such as Canada (Aaa stable), Russia (Ba1 negative), and Scandinavia, via higher agricultural yields, lower winter mortality, lower heating requirements, and a possible boost to tourism.[6]

Damage to Infrastructure: Climate shocks can inflict significant damage to the infrastructure assets of an economy. They may lead to the breakdown of supply chain networks and damage critical services such as electricity or water supply. Reconstruction costs can be large and impose a significant burden on public finances. Persistent climate shocks may also increase expenses related to adaptation and prevention.

The impact of a single event can be severe. The estimated value of disaster effects on Fiji's (B1 positive) economy from Tropical Cyclone Winston in early 2016 was approximately FJD1.99 billion ($0.9 billion), or 21% of 2015 nominal GDP, including FJD1.29 billion ($0.6 billion) in damage to physical assets and FJD0.71 billion ($0.3 billion) in losses.[7]

Floods in Mozambique (Caa3 negative) in 2015 resulted in critical damage to roads and bridges, cutting land access to almost 70% of the Zambézia province. Downed power cables and electricity towers also left several parts of northern Mozambique without power.[8]

Rising Social Costs: Climate trends and climate shocks may also raise social costs. Extreme flooding across highly populated low-lying areas often results in the spread of water-borne diseases and a deterioration in sanitary conditions. At the other end of the spectrum, sustained droughts can threaten food security and sufficient access to drinking water and irrigation, particularly in regions where agriculture makes up a large share of the local economy. Again, sovereigns are potentially exposed to such risks via the fiscal impact of higher spending requirements or, in extreme cases, the potential political, fiscal and economic implications of social unrest.

The severe El Nino-driven drought in Papua New Guinea (B2 stable) in 2015 affected more than 2 million people, or around one third of the population. The impact on food supply and the wider economy prompted the government to step in to buy rice, and provide drought assistance and disaster relief worth around PGK230 million, or 0.3% of GDP.[9]

Population Shifts: Finally, populations shifts can occur due to the forced displacement of human settlements resulting from climate change. Climate shocks may result in short-term internal displacements of populations. Sustained migration, meanwhile, may pose a long-term threat to countries where deteriorating climate trends are undermining local economies and livelihoods. The sovereign credit impact of significant population shifts will be felt through a tightening of labor markets, or outright shortages of labor. Migration can also have a negative impact on productivity to the extent that the more mobile part of the population is often more highly qualified and focused on higher value-added activities. On the other hand, long-term migration may also pose both opportunities and challenges for recipient countries.

The potential for population shifts as a result of climate change is elevated when combined with other socio-economic or political factors, such as social discontent. According to some studies, the prolonged drought in Syria (unrated) between 2006 and 2011 led to a large population displacement from rural to urban areas, a trend which contributed to the ongoing civil war.[10]

The credit implications of physical climate change are captured in a broad set of rating factors that influence a sovereign's ability and willingness to repay their debt

Our sovereign bond rating methodology does not separately account for physical risks posed by climate change.[11] Instead, we capture the potential impact from climate risks in the broad set of key rating factors – Economic Strength, Institutional Strength, Fiscal Strength and Susceptibility to Event Risk - which, collectively, influence sovereigns' ability and willingness to repay debt (Exhibit 3). [12]

Exhibit 3

Credit Impact of Physical Climate Change Captured in Key Rating Factors

Broad Rating Factor	Rating Sub-Factor	Factor Weighting	Impact of Climate Change Risks
Factor 1: Economic Strength	Growth Dynamics	50%	Weaker economic activity or damage to infrastructure due to climate trend/shock may impact GDP and/or potential GDP growth. High GDP concentration in sectors exposed to climate change risk (e.g. agriculture, tourism), and a geographic location in low lying densely populated coastal areas, increases susceptibility to climate change risks. Smaller, less diversified countries are particularly vulnerable.
	Scale of the Economy	25%	
	National Income	25%	
	Adjustment Factors	1 - 6 Scores	
Factor 2: Institutional Strength	Institutional Framework and Effectiveness	75%	Major climate shock may test institutional capacity to organize and deal with reconstruction costs. Proactive government policies to anticipate and prepare for climate-related shocks such as insurance against natural disasters or a savings fund would support the institutional capacity to deal with climate trends/shocks.
	Policy Credibility and Effectiveness	25%	
	Adjustment Factors	1 - 6 Scores	
Factor 3: Fiscal Strength	Debt Burden	50%	Fiscal strength may be challenged due to rise in social programs/current expenditures, reconstruction/mitigation costs, cost of displacement. Climate change risks could also represent a loss of government revenues due to lower economic activity and/or demographic shifts.
	Debt Affordability	50%	
	Adjustment Factors	1 - 6 Scores	
Factor 4: Susceptibility to Event Risk	Political Risk	Max. Function	Climate shock may be sufficiently disruptive to productive capacity or to government's balance sheet that it results in a sizable impact on economic and/or fiscal strength. In extreme instances, political risk may manifest itself through social tensions due to food shortages, health crises, destruction of livelihood or forced displacements. Countries exposed to elevated external vulnerability and climate change risks are doubly vulnerable, as the manifestation of a climate shock could trigger a loss of confidence amongst foreign investors.
	Government Liquidity Risk	Max. Function	
	Banking Sector Risk	Max. Function	
	External Vulnerability Risk	Max. Function	

Source: Moody's Investors Service

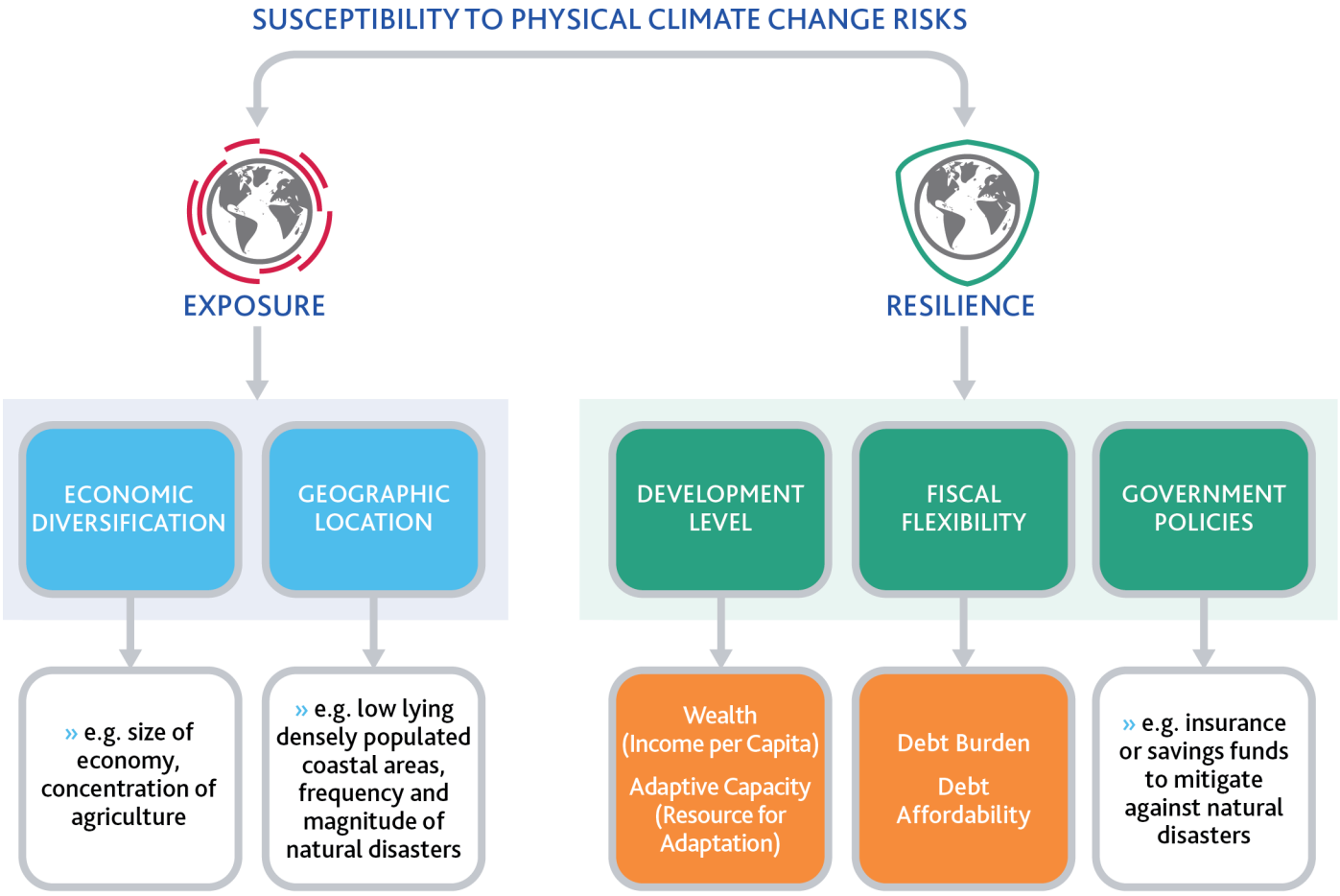
- **Economic Strength**, our methodology's first factor, captures a country's intrinsic economic or shock-absorption capacity to cope with adverse events, including climate-related disruptions. This factor implicitly captures the economic impact exposure by incorporating economic scale, diversity and wealth levels as indicators of the relative ability of a sovereign to generate revenue and ultimately service debt. As a rule, countries with high economic strength will be less exposed to climate-related shocks crystallizing, and less vulnerable to their impact when they do. Conversely, countries with low economic development levels, and often in consequence an important agricultural sector, tend to score low on economic strength and are more exposed to the lower, more volatile growth associated with exposure to climate trends and climate shocks. Sovereigns with greater economic concentration can also be more highly exposed to shocks which can result in lower nominal GDP over time, which may impact other sub-factors scored in our methodology.
- **Institutional Strength**, the second factor in our methodology, takes into account the government's economic and fiscal policy credibility, including its ability to develop the policies and institutional arrangements needed to foster stable economic growth and resilience to shocks. Unexpected, large-scale climate shocks may test a government's institutional capacity to deal with reconstruction costs. High institutional strength will tend to be associated with lower exposure and/or greater resilience to climate trends and climate shocks. The stronger rule of law and more effective policymaking and administrative institutions often found in countries with high institutional strength support the containment of exposure to climate change (for example, by developing greater economic diversity), and the enhancement of resilience through effective response to shocks when they occur. For countries most susceptible to climate change, our assessment of institutional strength will take into account, at least indirectly, the robustness of government policies aimed at anticipation, preparation and mitigation of climate change (for example, the existence of insurance or savings funds to compensate for natural disasters).
- **Fiscal Strength** captures the overall health of government finances and the capacity to absorb financial costs arising from economic and social disruptive events. Countries with higher fiscal strength tend to have greater access to larger and diversified funding sources and are better able to manage the financial consequences of one-off events, including climate shocks, without damaging their fiscal positions. In contrast, countries with lower fiscal strength tend to have less fiscal flexibility to deal with such shocks, given lower debt affordability, higher debt levels and/or limited funding sources. As such, countries with lower fiscal strength are in a weaker position to provide financial help to alleviate the impact of climate change, proving less resilient.
- **Susceptibility to Event Risk**, our final factor, evaluates a government's ability to withstand shocks from a medium-term perspective. It looks at features or trends which could potentially undermine a government's credit profile as some point in the future, but which have yet to crystallize with sufficient clarity to be reflected in the other factors. Climate change would be one such feature, particularly as its effects become more pronounced over time. In this context we look at four specific areas of event risk: Political Risk, Government Liquidity Risk, Banking Sector Risk and External Vulnerability Risk. While the threat posed by climate change falls less neatly into those categories, the economic, fiscal and social pressures that it can create may lead to outcomes which we would pick up here. For example, in smaller, open economies, the emerging prospect of a climate shock may undermine the near-term health of the government's finances (its liquidity), pose a threat to the resilience of the banking system or (in a country heavily dependent on external financing) undermine the confidence of external investors in the economy. In more extreme scenarios, climate change may exacerbate underlying political or geopolitical stability issues, leading to a material increase in political risk.

Sovereign susceptibility will depend on an issuer's exposure and resilience to climate change

A sovereign issuer's susceptibility to physical climate change risks is a function of its exposure and resilience (Exhibit 4).

Exhibit 4

Susceptibility to Climate Change is a Function of Exposure and Resilience



Source: Moody's Investors Service

We break down exposure into two sub-groups: economic diversification and geographic location. Economic diversification captures the extent to which an economy would be affected by climate trends or climate shocks. We look at the absolute size of the economy as a broad measure of economic diversification, and the concentration of agriculture as a share of total output and employment given that it is this sector which is typically most exposed to climate change.

A sovereign's geographic location can be closely linked to the probability of climate trends or climate shocks occurring. As such, we also gauge the magnitude and frequency of economic disruptive climate events occurring in a given country, as well as other key variables such as population density in low-lying areas.

To assess resilience, we focus on three sub-groups: development level, fiscal flexibility and government policies. Development level looks broadly at the resources available for adaption to climate change, which includes the quality of infrastructure and the country's income levels. Fiscal flexibility reflects a sovereign's capacity to carry extra debt to cope with any material physical damage.

Finally, the presence of government policies targeted to tackle climate change risks can enhance a sovereign's resilience to physical climate change risks significantly. In the Box below, we focus on natural disaster insurance or savings funds.

Box: Presence of natural disaster insurance or savings funds can enhance sovereign resilience to physical climate change risks significantly

The presence of natural disaster insurance or savings funds can enhance a sovereign's resilience to physical climate change risks significantly. Such contingencies can mitigate potential losses of income, and/or expedite the reconstruction of physical assets, following a climate shock. In addition, many countries have received large multilateral and bilateral aid and funding in the aftermath of a climate shock, which in turn has provided strong support to fiscal metrics.

Globally-orchestrated government policies include the Green Climate Fund, a mechanism established in 2010 to assist developing countries to counter climate change. The fund will help roll out pledges delivered at the Paris Agreement to provide at least $100 billion of annual financing by 2020 to help developing countries mitigate and adapt to climate change.[13]

Many countries operate government policies or initiatives on a standalone basis. By way of example, the National Flood Insurance Program in the US (Aaa stable) is a federal program which provides insurance against flooding of private and public structures. Mexico (A3 negative), meanwhile, established the Fund for Natural Disasters (FONDEN) in 1996 to provide adequate financial resources for reconstruction and relief efforts in the event of natural disasters. FONDEN issued Mexico's first catastrophe bond in 2006.

Regional insurance pools are typically employed in cases where a natural disaster may overwhelm the capacity of the public and private sectors in an individual country to provide sufficient coverage. Two such examples are the African Risk Capacity (ARC) and the Caribbean Catastrophe Risk Insurance Facility (CCRIF). The ARC is a specialized arm of the African Union, which helps member states improve their ability to prepare and respond to climate change. Using participating countries' premiums and partner contributions, the ARC aims to reach $1.5 billion in coverage for as many as 30 countries by 2020. The CCRIF operates along similar lines, providing financing to mitigate the impact of hurricanes, floods and earthquakes in the Caribbean. Between 2007 and 2015, it paid out $37.9 million to eight member countries.[14] So far, governments in Asia have relied on post-disaster funding, in the absence of broad national or regional insurance funds.

While all countries will experience the physical effects of climate change to some degree, sovereigns with larger, more diversified economies and geographies are less susceptible. These economies generally have better infrastructure quality that can withstand disruptive events and an ability to carry a higher debt burden at more affordable interest rates. In contrast, those with a greater reliance on agriculture, lower incomes, weaker infrastructure quality, and smaller fiscal capacity exhibit greater susceptibility.

The importance of a country's size and diversification, both economically and geographically, in terms of reducing climate change susceptibility is borne out in past data. As Exhibit 5 illustrates, while countries with large economies and landmasses have experienced a greater frequency of climate-related natural disasters on average over the past decade, the relative impact of such disasters on GDP is also much less pronounced.

Exhibit 5

Countries with High Frequency of Natural Disasters Tend to be Large Economies, but Average Damage Largest in Smaller Ones

Moody's Rated Countries with Highest Frequency of Disasters			Moody's Rated Countries with Largest Damage from Disasters		
Country	# of Climate Related Disasters (Avg. 10 yr)	Damage Amount (% of GDP, Avg. 10 yr)	Country	# of Climate Related Disasters (Avg. 10 yr)	Damage Amount (% of GDP, Avg. 10 yr)
China	25.0	0.21	Maldives	1.0	6.20
United States	22.7	0.19	Saint Vincent & the Grenadines	1.3	1.80
Philippines	17.8	0.68	Thailand	3.6	0.99
India	15.1	0.20	Oman	1.0	0.97
Indonesia	9.8	0.08	Pakistan	5.0	0.91
Vietnam	6.6	0.53	El Salvador	2.0	0.87
Mexico	6.0	0.18	Moldova, Republic of	1.2	0.80
Japan	5.7	0.04	Fiji	2.0	0.69
Brazil	5.3	0.06	Philippines	17.8	0.68
Bangladesh	5.2	0.27	Cambodia	1.3	0.67

Note: We categorize disasters related to climate change as including drought, extreme temperature, flood, landslide, storm and wildfire.
Source: Natural Disaster Database

Macroeconomic variables and independent indices illustrate sovereigns' relative susceptibility to climate change effects

We have compiled a list of macroeconomic variables and independent indices to illustrate the relative susceptibility of rated sovereigns to the effects of physical climate change. See Appendix B for full details of the metrics used.

We use the Notre Dame Global Adaptation Index (ND-GAIN) Vulnerability country indices, which assess a country's exposure, sensitivity, and capacity to adapt to climate change. The exposure sub-index includes projected changes in populations, climate change and biodiversity. The sensitivity sub-index focusses on specific vulnerabilities within a country, such as dependency on food imports or the share of population living in areas more than 5 meters below sea level. Finally, the adaptive capacity index comprises of indicators that evaluate the quality of infrastructure (e.g. access to electricity) and government policies (disaster preparedness).

We also include a number of indicators used in our sovereign bond methodology that are specifically linked to climate change susceptibility. These include the scale of the economy (as measured by nominal GDP), national income (GDP per capita), and our assessment of Fiscal Strength.

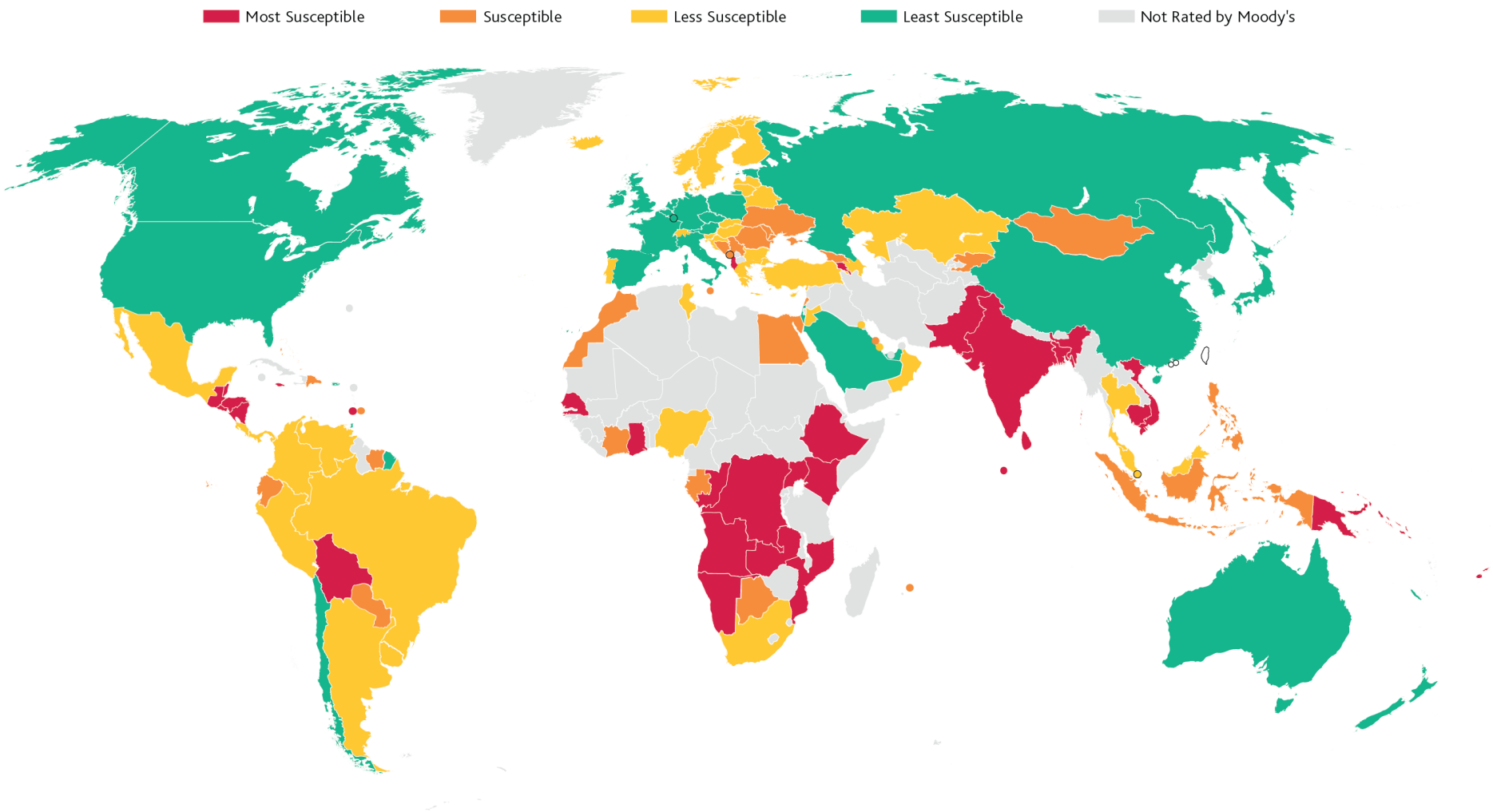
Our illustrated approach is not intended to be exhaustive. For instance, it does not capture the exposure of a specific climate hazard, or regional deviations within a country.

We also do not include the existence of insurance or savings funds to mitigate natural disasters due to the lack of consistent benchmark and, as mentioned earlier, such policies can enhance a country's resilience to the credit impact of climate change significantly.

However, the data we have used are widely available for the vast majority of sovereigns we cover, which allows for a cross-comparison. Exhibit 6 illustrates the relative susceptibility of sovereigns globally to the credit risks arising from physical climate change, while Exhibit 7 focusses on those sovereigns that these data would suggest are the most susceptible.

Exhibit 6

Susceptibility to Physical Climate Change of Moody's-Rated Sovereigns Based on Illustrative Data



Note: We apply a 70% weighting for "Exposure" and 30% for "Resilience" to all Moody's rated sovereigns. In each sub-category, the indicators are equal weighted. When data for one indicator (e.g. agricultural employment) is missing, we only consider other indicators in that sub-category. Data as of October 27.
Source: Moody's Investors Service; see Appendix B for details on indicators and sources

Exhibit 7

Rated Sovereigns Most Susceptible to Physical Climate Change Based on Illustrative Data

		'Exposure' to Climate Change Risk							**'Resilience'** to Climate Change Risk					
		Economic Diversification			Geographic Location				Development Level		Fiscal Flexibility			
												Selected F3 Sub-Indicators		
Country	LT Issuer Rating	Nominal GDP	Agricultural Employment	Agricultural Total Value Added	ND-GAIN Exposure	ND-GAIN Sensitivity	# Annual Disaster*	Annual Damage*	GDP per capita	ND-GAIN Capacity	F3 Fiscal Strength	Gen. Gov. Debt	Gov. Interest Payments	Fiscal Deficit
		(US$ Bn) 2015	(% Labor Force) 2011-14 (avg)	(% GDP) 2011-14 (avg)	Score 2014	Score 2014	(avg. 10yr) 2006-15	(% GDP) 2006-15	(PPP 2015	Score 2014	Score 2015	(% GDP) 2015	(% Revenue) 2015	(% GDP) 2015
Albania	B1	11	--	22.00	0.48	0.38	1.60	-	11,358	0.50	L-	72	10.09	-3.95
Angola	B1	122	--	11.00	0.57	0.38	2.11	-	7,344	0.75	M-	44	9.55	-1.63
Armenia	B1	11	37.50	21.11	0.45	0.35	2.00	0.06	8,468	0.41	M-	49	6.27	-4.61
Bangladesh	Ba3	195	--	16.80	0.53	0.43	5.20	0.27	3,398	0.64	M	27	18.32	-4.66
Belize	Caa2	2	--	14.78	0.50	0.44	1.25	0.18	8,373	0.44	VL	78	9.56	-10.41
Bolivia	Ba3	33	--	12.93	0.52	0.32	2.50	0.46	6,465	0.55	H-	40	3.00	-6.61
Cambodia	B2	18	--	34.06	0.38	0.50	1.25	0.67	3,488	0.64	M-	35	2.24	-1.99
Congo	B3	9	--	4.13	0.52	0.50	1.33	-	6,722	0.79	L+	46	1.92	-11.08
Congo, the Democratic Republic of	B3	40	--	22.62	0.51	0.56	2.44	0.00	770	0.88	H-	13	2.24	0.16
El Salvador	B1	26	20.73	11.68	0.49	0.36	2.00	0.87	8,303	0.49	M	61	12.41	-3.29
Ethiopia	B1	61	30.13	44.87	0.53	0.44	2.44	0.00	1,801	0.75	M-	49	3.87	-2.90
Fiji	B1	4	--	11.42	0.53	0.55	2.00	0.69	9,044	0.52	M	47	11.12	-4.13
Ghana	B3	37	44.70	23.79	0.53	0.38	1.43	0.00	4,266	0.55	VL-	71	29.19	-6.74
Guatemala	Ba1	64	34.20	11.43	0.54	0.37	3.11	0.26	7,738	0.48	M+	24	12.92	-1.44
Honduras	B2	20	36.87	14.21	0.50	0.40	2.00	0.06	4,869	0.51	L-	46	13.74	-3.09
India	Baa3	2,074	48.40	18.12	0.54	0.32	15.10	0.20	6,187	0.55	L	67	21.22	-6.45
Jamaica	Caa2	14	17.97	6.85	0.53	0.44	1.33	0.41	8,759	0.43	VL-	126	28.28	-0.52
Kenya	B1	61	--	29.52	0.47	0.47	3.50	0.02	3,208	0.73	L-	50	15.54	-8.85
Maldives	B2	3	--	3.83	0.74	0.50	1.00	6.20	14,923	0.35	L+	64	7.43	-6.93
Mozambique	Caa3	15	--	27.07	0.49	0.51	2.67	0.20	1,186	0.69	VL-	85	4.79	-5.98
Namibia	Baa3	12	29.53	7.90	0.56	0.50	1.22	0.07	10,556	0.62	M+	36	4.22	-5.23
Nicaragua	B2	13	--	19.23	0.50	0.36	2.00	-	4,997	0.45	M+	30	3.77	-1.78
Pakistan	B3	267	44.10	25.11	0.49	0.45	5.00	0.91	4,971	0.47	VL-	63	32.77	-5.13
Papua New Guinea	B2	23	--	--	0.53	0.66	1.89	0.04	3,495	0.89	M+	28	9.80	-3.95
Saint Vincent and the Grenadines	B3	1	--	7.51	0.54	0.48	1.33	1.80	10,937	0.48	VL+	69	8.05	-2.84
Senegal	B1	14	46.10	15.96	0.51	0.54	1.25	0.01	2,451	0.62	L-	57	7.53	-4.82
Solomon Islands	B3	1	--	--	0.57	0.79	1.43	0.25	1,950	0.69	H	9	0.48	-0.31
Sri Lanka	B1	82	31.47	8.59	0.45	0.45	3.20	0.09	10,566	0.51	VL-	76	34.89	-7.42
Uganda	B1	26	71.90	25.79	0.51	0.58	1.86	0.00	1,740	0.71	L+	35	11.75	-4.46
Vietnam	B1	195	47.10	18.61	0.50	0.39	6.60	0.53	6,037	0.45	L+	49	8.37	-5.88
Zambia	B3	22	52.20	9.83	0.61	0.43	1.43	-	3,868	0.60	VL	50	15.48	-8.13

Note: We apply a 70% weighting for "Exposure" and 30% for "Resilience" to all Moody's rated sovereigns. In each sub-category, the indicators are equal weighted. When data for one indicator (e.g. agricultural employment) is missing, we only consider other indicators in that sub-category. Data as of October 27. *We categorize disasters related to climate change as including drought, extreme temperature, flood, landslide, storm and wildfire.
Source: Moody's Investors Service; see Appendix B for details on indicators and sources

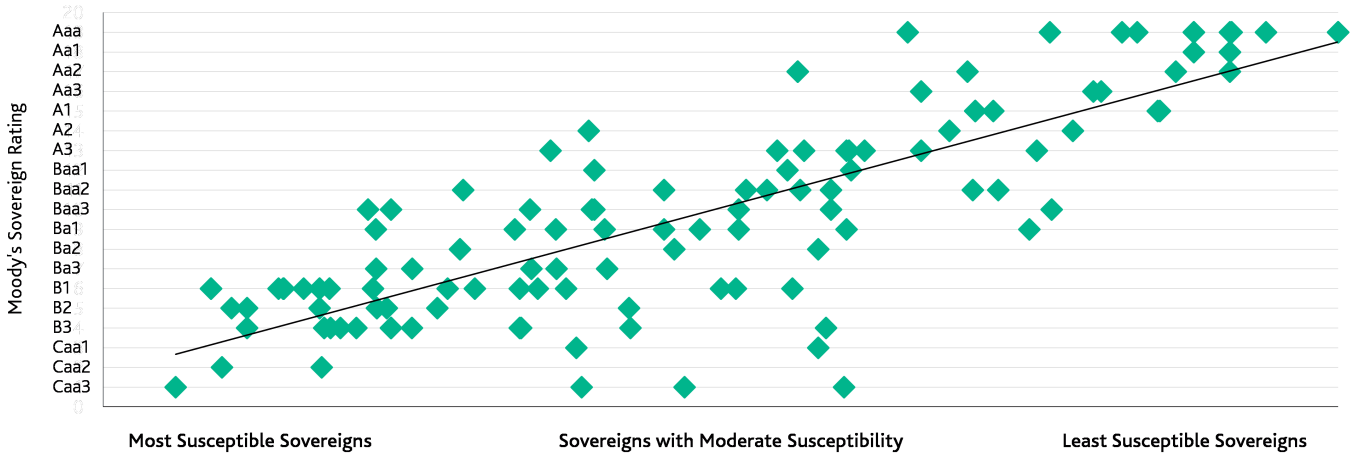
Countries susceptible to climate change risks are generally lower rated

As would be expected, given the overlap illustrated earlier between the factors we take into account in assessing sovereign credit profiles and those driving exposure and resilience to climate change, sovereigns' ratings are quite strongly correlated with their susceptibility to climate change as defined in this Comment (Exhibit 8).

Exhibit 8

Strong Correlation between Climate Change Susceptibility and Sovereign Creditworthiness

Moody's Sovereign Ratings vs. Climate Change Susceptibility

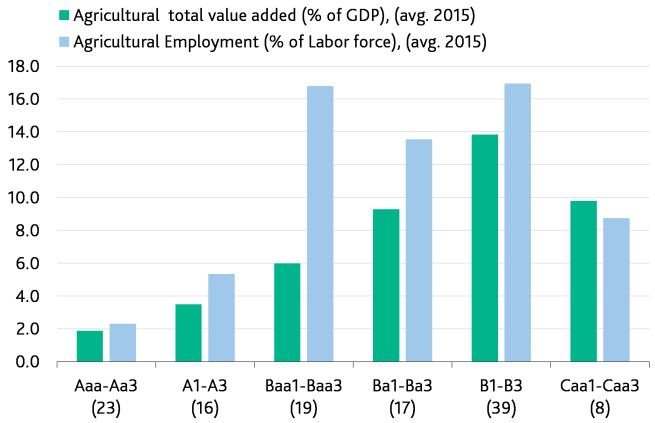


Note: Data as of October 27.
Source: Moody's Investors Service

However, as Exhibits 9 and 10 illustrate, it also reflects the fact that countries with an overarching reliance on agriculture and where the quality of infrastructure is typically weaker – two important aspects of susceptibility to physical climate change – tend to be lower rated.

Exhibit 9

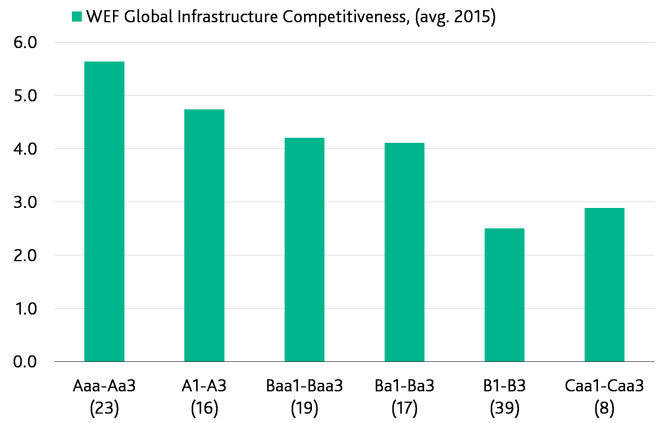
Economies More Reliant on Agriculture Tend to be Lower Rated…



Note: Numbers in parentheses indicate the number of sovereigns included within each rating range as of October 27.
Sources: World Bank, Moody's Investors Service

Exhibit 10

…as do Those With Weaker Infrastructure Quality



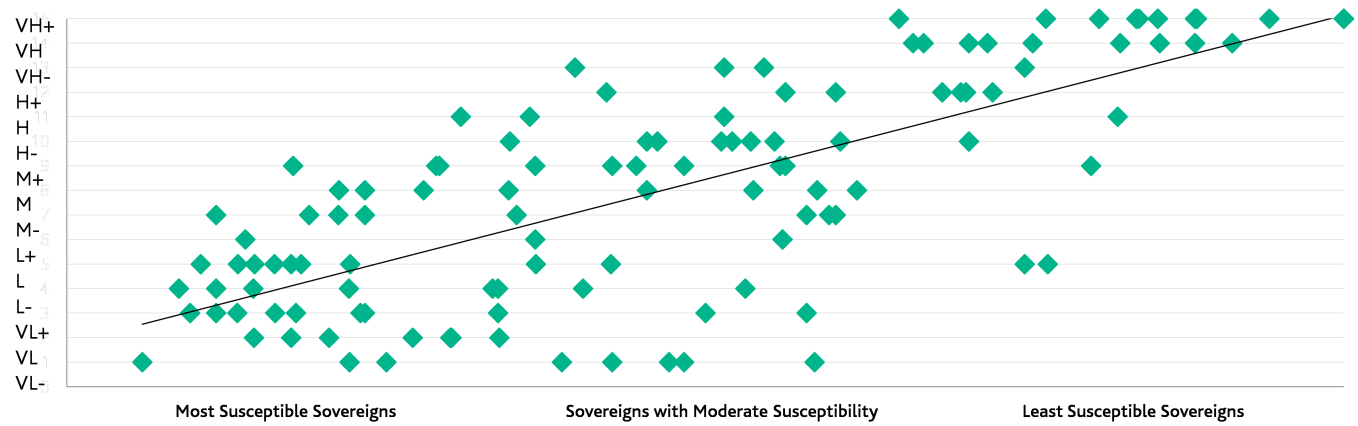
Note: Numbers in parentheses indicate the number of sovereigns included within each rating range as of October 27.
Sources: World Economic Forum, Moody's Investors Service

Another important observation is that institutional strength is generally higher amongst sovereigns with a lower susceptibility to physical climate change (Exhibit 11). While our assessment of institutional strength is from a much broader perspective, the strong correlation reinforces our view that a stronger rule of law and more effective policymaking and administrative institutions often support the containment of climate change risks.

Exhibit 11

Institutional Strength Is Higher in Countries with Low Susceptibility to Climate Change

Moody's Institutional Strength Factor Score vs. Climate Change Susceptibility



Source: Moody's Investors Service

Sovereign credit implications will build over time

As we have shown, therefore, climate change already exerts some influence on the credit profiles, and hence ratings, of those sovereigns that are the most susceptible to its effects. Accordingly, as a slowly-evolving influence, climate change does not have near-term implications for sovereign ratings.

However, the effect of climate change, and hence its impact on sovereign credit profiles, is projected to grow over time. We will monitor closely the evolving impact and will update and amend our credit assessment of sovereign exposure and resilience to climate change as needed. How quickly, and how severely, the impact of climate change grows will depend on the speed and effectiveness of the global response to climate change.

In that respect, the future is uncertain. The Paris Agreement entered into force on November 4. The agreement represents a landmark global pact on climate change with 192 signatories, even as the combined effects of submitted Nationally Determined Contributions (NDCs) country commitments are acknowledged to fall short of achieving the agreement's goals of holding the increase in the global average temperature to well below 2°C above pre-industrial levels. As Exhibit 12 illustrates, country commitments outlined in the Paris Agreement – which form the basis of our central scenario for the future trajectory of carbon emissions – are currently forecast to be insufficient to limit temperatures from rising more than 2°C above pre-industrial levels.

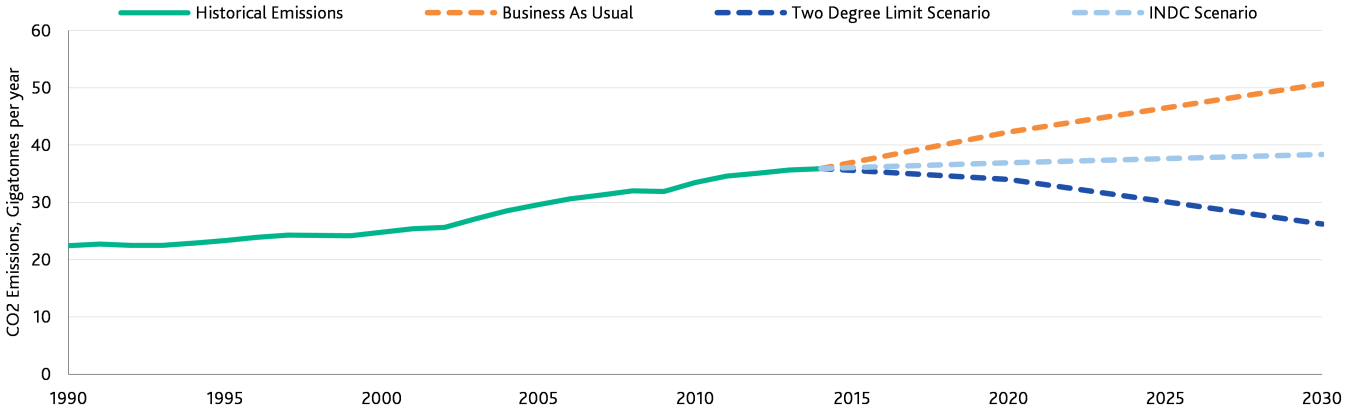
The Paris Agreement includes a ratcheting mechanism which could create momentum for further commitments in the future. And more recently, the announcement of a global agreement to implement a Carbon Offset and Reduction Scheme for International Aviation and, more importantly, a global deal to limit the use of hydrofluorocarbons serve to bolster the Paris Agreement.

Still, significant uncertainty exists over the magnitude and pace of carbon emission policies and their effects during the term of the agreement and beyond. In the meantime climate change is expected to become an increasingly dominant factor in our analysis of the credit profiles of those sovereigns that are most susceptible to its effects over the coming decades.

Exhibit 12

Paris Agreement Commitments Are Currently Insufficient to Limit Temperatures from Rising More than 2°C Above Pre-Industrial Levels

CO_2 Emissions, Gigatonnes per year



Note: "Business as usual" and "Two degree limit" scenarios are sourced from the Carbon Dioxide Information Analysis Centre. The INDC Scenario is based on data from the International Energy Agency.

Sources: Moody's Investors Service, Carbon Dioxide Information Analysis Centre, International Energy Agency

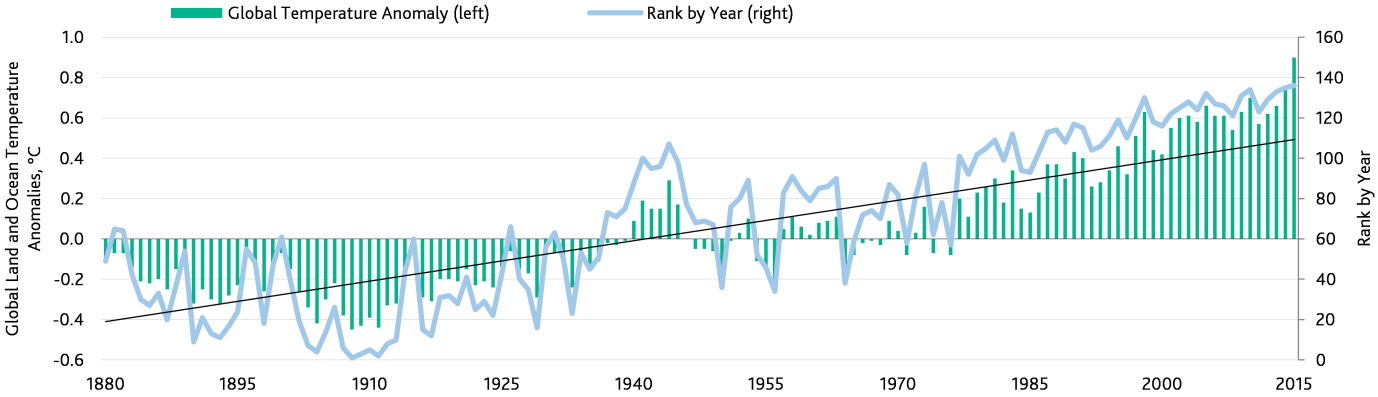
Appendix A – Background on Climate Change

According to the US government, the globally averaged temperature in 2015 was the highest since record keeping began in 1880 (Exhibit 13).[15] The average temperature across global land and ocean surfaces was 1.62°F (0.90°C) above the 20th century average, and was the highest among all years in the 1880-2015 record, surpassing the previous record set last year by 0.29°F (0.16°C).

Exhibit 13

Global Temperatures in 2015 Were the Highest on Record

Global Land and Ocean Temperature Anomalies, 1880-2015



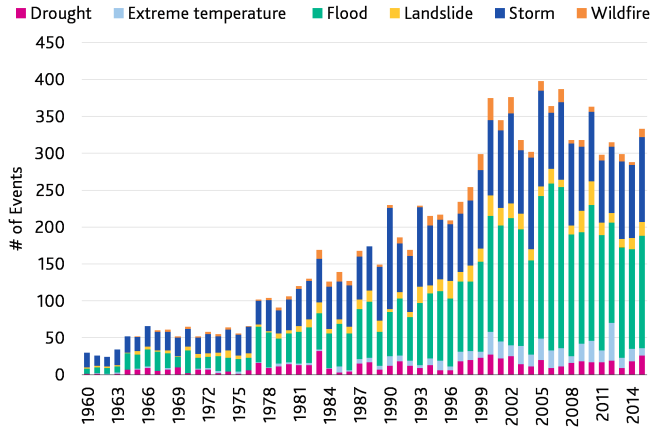
Note: Global and hemispheric anomalies are with respect to the 20th century average. Continental anomalies are with respect to the 1910 to 2000 average.
Sources: Moody's Investors Service, NOAA National Centers for Environmental information

Meanwhile, natural disasters occurring globally are increasing in terms of frequency and total damage incurred (Exhibits 14 and 15).

Exhibit 14

Natural Disasters Are Rising in Frequency...

Numbers of Natural Disasters Globally

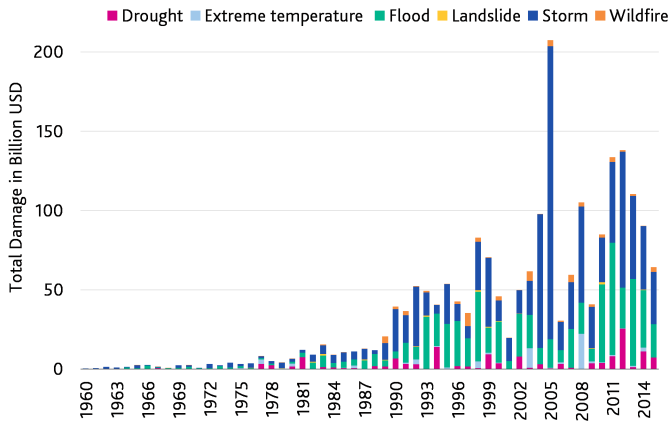


Sources: EM-DAT International Disaster Database 2016, Moody's Investors Service

Exhibit 15

...And Total Damage Is Rising in Magnitude

Total Damage from Natural Disasters, $ Billion



Sources: EM-DAT International Disaster Database 2016, Moody's Investors Service

These trends are expected to continue given the broad scientific agreement about the link between the level of greenhouse gas (GHG) in the atmosphere and the ongoing increase in surface air temperature, sea levels, and ocean acidification.[16]

As reported by the Intergovernmental Panel on Climate Change (IPCC), "It is extremely likely that more than half of the observed increase in global average surface temperatures from 1951 to 2010 was caused by the anthropogenic increase in GHG concentration and other anthropogenic forcing together."[17]

The IPCC noted that "Multiple lines of evidence indicate a strong, consistent, almost linear relationship between cumulative CO_2 emissions and projected global temperature change to the year 2100…".[18]. It further reports that the risks of climate change are considerable at 1°C- 2°C degrees above pre-industrial levels and increase substantially as temperature rise beyond this level.

Scientific studies show that there is still some uncertainty about the specific implications of further GHG emission for atmospheric temperatures. This is reflected in the wide range of likely impacts around the mean estimated warming for a given GHG emission scenario. This means that any estimate of the risk of climate change under a given GHG emission pathway should also contemplate the possibility of a more (or less) severe adverse outcome. It is also worth noting that a recent study, using revised modeling of Antarctica's ice sheet, projects global sea level rise that could be almost twice as large as those reported by the IPCC.[19]

Appendix B – Details on Indicators Used to Illustrate Climate Change Susceptibility of Rated Sovereigns

Sub-factor Indicator (Unit)	Note
Nominal Gross Domestic Product (US$)	Source: IMF, Eurostat, AMECO, Official National Sources, Moody's
Employment in Agriculture (% of Total Employment)	Source: International Labor Organization, World Bank
Agriculture, Value Added (% of GDP)	Source: OECD, World Bank. Note: For Angola, data from source was missing; therefore, we use US Department of Agriculture.
ND-GAIN Vulnerability Index: Exposure Component (Index) 1	Source: Notre Dame Global Adaptation Index (ND-GAIN): Vulnerability Index The nature and degree to which a system is exposed to significant climate change. A component of vulnerability independent of socio economic context.
ND-GAIN Vulnerability Index: Sensitivity Component (Index) 1	Source: Notre Dame Global Adaptation Index (ND-GAIN): Vulnerability Index The extent to which a country is dependent upon a sector negatively affected by climate hazard, or the proportion of the population particularly susceptible to a climate change hazard.
Numbers of climate change related disasters (10 year average, Frequency)	Source: Centre for Research on the Epidemiology of Disasters (CRED) Emergency Events Database (EM-DAT), Moody's Number of disasters related to climate change events. These include drought, extreme temperature, flood, landslide, storm and wildfire.
Damage Amount of climate change related disasters (10 year average, % of GDP)	Source: Centre for Research on the Epidemiology of Disasters (CRED) Emergency Events Database (EM-DAT), Moody's For each climate change related disaster (drought, extreme temperature, flood, landslide, storm and wildfire.), the registered figure corresponds to the damage value at the moment of the climate change related event as a percentage of GDP. Note: For Maldives, EM-DAT data was missing; therefore, we use the government source.
GDP per capita (PPP, US$)	Source: IMF, Moody's
ND-GAIN Vulnerability Index: Adaptive Capacity Component (Index) 1	Source: Notre Dame Global Adaptation Index (ND-GAIN): Vulnerability Index The availability of social resources for sector-specific adaptation. In some cases, these capacities reflect sustainable adaptation solutions. In other cases, they reflect capacities to put newer, more sustainable adaptations into place.
Government Fiscal Strength (Score)	Source: Moody's Sovereign Scorecards
General Government Debt (% of GDP)	Source: IMF, OECD, Eurostat, AMECO, National Sources, Moody's
Gen. Govt. Interest Payments/General Government Revenues (%)	Source: IMF, OECD, Eurostat, AMECO, National Sources, Moody's
Government Fiscal Deficit (% of GDP)	Source: IMF, OECD, Eurostat, AMECO, National Sources, Moody's

1 The ND-GAIN vulnerability index defines vulnerability as (A) exposure and (B) sensitivity to climate, population, infrastructure and resource stress, as well as the country's (C) adaptive capacity to those stresses. Each sub-indicator measures overall score by considering 6 impacted areas from rising environmental risk: (1) food; (2) water; (3) health; (4) ecosystem service; (5) human habitat; and (6) infrastructure.

Moody's Related Research

- Rating Methodology: Sovereign Bond Ratings, December 2015 (186644)
- Environmental Risks: Paris Agreement to Take Effect, Adoption of Carbon Reduction Policies to Accelerate, October 2016 (1044876)
- Global Unregulated Utilities and Power Companies: Carbon Transition Brings Risks and Opportunities, October 2016 (1030584)
- Environmental Risks: Automotive Sector Faces Rising Credit Risks from Carbon Transition, September 2016 (1038590)
- Environmental Risks: Risks and Opportunities: What the Paris Agreement Means for Capital Markets, July 2016 (1033890)
- Environmental Risks and Developments – Moody's To Analyse Carbon Transition Risk Based On Emissions Reduction Scenario Consistent with Paris Agreement, June 2016 (1029574)
- Environmental Risks and Developments – Global: Paris Agreement Advances Adoption of Carbon Regulations; Credit Impact to Rise, April 2016 (1024553)
- Moody's Approach to Assessing the Credit Impacts of Environmental Risks, November 2015 (1010009)
- Environmental Risks: Heat Map Shows Wide Variations in Credit Impact Across Sectors, September 2015 (1009845)
- Environmental, Social and Governance (ESG) Risks - Global: Moody's Approach to Assessing ESG Risks in Ratings and Research, September 2015 (1007087)

To access any of these reports, click on the entry above. Note that these references are current as of the date of publication of this report and that more recent reports may be available. All research may not be available to all clients.

Endnotes

1 While not the subject of this report, Moody's also considers the credit implications of carbon transition risks; that is, the credit impact of increased costs and business model adjustments associated with the trend towards materially reducing global greenhouse gas (GHG) emissions, including for carbon. Please see Environmental Risks: Moody's To Analyse Carbon Transition Risk Based On Emissions Reduction Scenario Consistent with Paris Agreement, June 2016.

2 The Intergovernmental Panel on Climate Change (IPCC) was created by the United Nations Environmental Panel and the World Meteorological Organization in 1988. It does not conduct independent research, but produces a consensus of research published in the world.

3 See Climate Change 2014 Synthesis Report (IPCC), 2015.

4 See India, Government of Vulnerability to Drought Poses Credit Challenges, August 2015.

5 See Economic Costs to Lebanon from Climate Change: A First Look, Ministry of Environment – United Nations Development Programme, 2015.

6 See Stern Review: The Economics of Climate Change, 2006.

7 See Fiji: Post-Disaster Needs Assessment, May 2016 - Tropical Cyclone Winston, February 20, 2016.

8 See http://www.unicef.org/appeals/files/UNICEF_Update_Mozambique_Flooding_Emergency_in_Zambezia_Jan2015.pdf, January 2015.

9 The government directly allocated PGK50 million for disaster relief in the 2016 budget, see http://www.treasury.gov.pg/html/national_budget/files/2016/2016%20Budget%20Speech.pdf. Furthermore, according to reports, the government is also channelling an additional PGK176 million into district authorities for drought-related assistance, see http://devpolicy.org/politicising-drought-relief-in-papua-new-guinea-20160118/.

10 See Kelley, et al. (2015) 'Climate change in the Fertile Crescent and implications of the recent Syrian drought'.

11 For greater detail on our methodology, see Rating Methodology: Sovereign Bond Ratings, December 2015.

12 Rating outcomes may consider additional factors that are difficult to measure or that have a meaningful effect in differentiating credit quality only in some, but not all cases. While these are important considerations, it is not possible to express them precisely in the rating methodology scorecard without making it excessively complex and significantly less transparent.

13 See http://unfccc.int/bodies/green_climate_fund_board/body/6974.php.

14 See CCRIF Annual Report 2014-2015, November 2015.

15 See State of Climate Report, December 2015, National Centers for Environmental Information, US Department of Commerce.

16 See John Cook et al, Consensus on consensus: a synthesis of consensus estimates on human-caused global warming, Environmental Research Letters, April 13, 2016.

17 The IPCC defines "extremely likely" as having an assessed 95% to 100% likelihood.

18 See Climate Change 2014: Synthesis Report, 2015 IPCC

19 See Robert M. DeConto and & David Pollard, Contribution of Antarctica to past and future sea-level rise, Nature 531, 591–597, published online 30 March 2016, corrected online 05 April 2016.

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