Using risk transfer to achieve climate change resilience

A special report sponsored by Nephila

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Contents

Introduction2	
What are catastrophe and weather risk transfer contracts?	
Overview: risk transfer as a tool for climate change adaptation4	
Risk transfer for climate change adaptation in the developed world	
Large corporations need new tools to assess and manage climate risks5	
Water utilities explore risk transfer to manage costs of weather volatility7	
Transit agencies approach catastrophe and weather risk transfer cautiously8	
Risk transfer to support resiliency in the developing world10	
World Bank leads large-scale risk transfer transactions11	
Farmer-focused weather index insurance to protect the most vulnerable	
"Smallsats" and weather data science can enable growth of weather index-insurance16	
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16	
Additional findings and conclusions	
Sources cited	

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Introduction from Barney Schauble Chairman, Nephila Climate

At Nephila, we match institutions who are seeking noncorrelated investment strategies with organizations that want to reduce their exposure to weather and catastrophe risks. This simple concept was the basis for the insurancelinked securities (ILS) industry, and it's grown from virtually nothing (when we were founded in 1998), to a point today where ILS is the source of about 15 percent of reinsurance risk capacity globally.

We have traditionally focused on natural hazards: both routine weather variations—like the warmer-than-usual weather that blanketed Europe and the UK in the winter of 2018/2019—and catastrophic activity, such as the 2017 and 2018 Atlantic hurricanes that caused almost \$100 billion in insured damage in the United States.

We created our first vehicle to invest specifically in weather risk in 2005, and today Nephila is the largest investment manager in both the catastrophe and weather risk markets. So we have a pretty strong grasp of how weather risks are shifting with the changing climate.

Uncertainty exists around how much of a role climate change plays in any specific extreme weather event, but climate science is increasingly clear—climate change will make certain extreme weather events more frequent and more destructive. Droughts and heat waves will be longer and more severe. Precipitation will be more intense and the resulting floods more damaging.

A growing number of corporations, institutions and investors—not to mention NGOs and governments—are focused on how to implement the Paris Agreement and prevent the worst consequences of climate change. I'm proud to serve on the board of Ceres, an NGO that coordinates networks of companies and investors to focus on sustainability in capital markets.

But regardless of how successful we are at reducing greenhouse gas emissions over the coming years, the climate trends already set in motion will persist for decades, making adaptation mandatory and inevitable.

We launched Nephila Climate as a dedicated subsidiary business in 2017 to highlight that there is a real and growing business in providing risk capacity by creating new weather-linked investment products. We see this as a resilient, long-term, non-zero-sum market. Institutions can achieve the results they want, improving their portfolios by investing in insurance-linked securities, the performance of which is not correlated with broader financial and alternative markets; at the same time, we can use that capital to provide protection against weather and climate risks for vulnerable communities and businesses.

The potential benefits of this model are applicable across geographies and sectors. The benefits of risk transfer can already be seen in the developing world. For example, in India and Africa, better risk management creates resilience in the face of drought and flood. Our investors have provided risk capital for small-farmer insurance initiatives in these markets through the African Risk Capacity initiative, WorldCover, and other pathways described in this report.

For sovereign governments, risk transfer can make an entire nation more stable and credit-worthy in the face of hurricanes or other natural disasters. To that end, our investors have supported large-scale risk transfer contracts for Uruguay, Mexico and other sovereign governments/countries.

New risk transfer products enable financing of wind, solar, and hydro-electric generation in the US, Australia, and Europe. In the developed world, we've built a robust business selling weather risk transfer to companies in highly weather-sensitive industries—primarily electric and gas utilities, renewable power and agriculture. We're getting more inquiries every month from financial managers in other industries, as well as in government, who want to learn more about their risk transfer options.

Many of these managers are understandably reluctant to budget more money for weather risk transfer or catastrophe coverage. These transactions can sound complex, and for a manager who has never participated in this market, taking the first step can be intimidating. We find that one of the principal obstacles to broader adoption of this type of protection is that most people simply don't know about the available options in this market. That's why we commissioned this report.

Barney Schauble Chairman Nephila Climate

Introduction2
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world5
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited 21



What are catastrophe and weather risk transfer contracts?

Insurance has been a core part of financial markets for hundreds of years. In its most basic form, insurance is the transfer of risk from someone who is exposed to bad fortune to another party which can better absorb the impact. The first insurance policies were created in the 17th century by London ship captains around a table at Edward Lloyd's coffee house where they began pooling their risks to share potential losses. Over time this led to a market of professional risk takers who would cover marine and other risks as part of a dedicated business.

Reinsurance—insurance for insurance companies—was created in the mid-nineteenth 19th century when a fire that destroyed Cologne revealed that a single event could overwhelm the pooled risk capital in a specific city or country. This led to the creation of internal markets for reinsurance in which countries had a state- or publicly-owned ultimate risk taker: Munich Re, Swiss Re, General Re.

As property and businesses grew, evolved, and became more exposed to risk, a specialized industry of insurance and reinsurance, complete with many advisors and consultants, developed to enable risk transfer for these exposures.

Catastrophe and weather risk transfer (WRT) instruments are newer, 21st-century creations that transfer risks from one party (the buyer of protection who "cedes" risk, or the "cedent") to another, usually an investor or investment manager. These contracts function much like traditional insurance: in return for the payment of a premium, cedents receive the promise of payment if some defined outcome occurs. But unlike most insurance—which is governmentregulated, offered in standard forms and with generic common contract terms—catastrophe and WRT instruments are typically customized to meet the specific risk exposures and financial needs of a cedent, and are not necessarily documented as re/insurance.

Catastrophe-linked instruments such as catastrophe bonds transfer the risk of events that occur infrequently but can cause major damage (for example, earthquakes and hurricanes), from a sponsor/cedent to the capital markets. Investors receive premiums from the sponsor (as yield on the bonds) in exchange for guaranteeing to reimburse the sponsor—up to a specified maximum—if the covered perils occur in the specified term, typically one to three years. Catastrophe bonds ("cat bonds") are the most common form of catastrophe risk transfer and are usually sponsored by insurance and reinsurance companies seeking to augment the risk capacity available to them from more traditional sources. But in the last 10 to 15 years, sovereign and sub-national governments—aided by the World Bank in most cases—and some U.S. public agencies have used cat bonds as well, to secure protection against the impact of extreme events.

Weather risk transfer (WRT) contracts protect cedents against the impacts of both routine weather variability and weather extremes, rather than destruction of property. The WRT market was first adopted by users in highly weather-sensitive industries like electric and gas utilities, renewable power, and agriculture that have a finely tuned understanding of how weather affects their earnings. More recently, the market has expanded to include water utilities and firms in construction, mining, outdoor entertainment, and other industries where weather can affect financial performance but is not (yet) a primary focus.

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change18

Overview: Risk transfer as a tool for climate change adaptation

As businesses and communities explore strategies to manage new and emerging weather risks and adapt to the changing climate, the topic of risk transfer comes up more frequently. Extreme weather and climate change in some regions is already making insurance more expensive and difficult to obtain. In California, several insurers have stopped writing new policies and renewals in the state's "wildland-urban interface"—and this occurred in 2017, before the catastrophic 2018 wildfires. ¹

Many U.S. local governments are under pressure to improve flood defenses or see their residents' insurance increase dramatically. Some already face litigation like the 2014 lawsuits brought by Farmers Insurance Group against dozens of Chicago-area local governments. Farmers dropped the lawsuits but never backed down from its contention that the cities should have done more to prepare for the flooding that their own climate reports had predicted. ^{2 3}

On the other side of the equation, insurers are facing new questions from regulators about how prepared they are to cover the potential increase in losses from weather made worse by climate change. Reinsurance firms—which provide backup risk capacity to primary insurers—have been speaking publicly about climate risks for more than 10 years, urging governments to take action to mitigate greenhouse gas emissions and adapt to the changing climate.

Often left out of this important public discussion is one vital fact:

Risk transfer is also a tool for adapting to climate change.

At the most basic level, pricing of risk should be the best reflection of how risk is changing. The prospect of saving on insurance costs can incentivize governments to invest in resilience measures. In Queensland, insurers reduced premiums for flood coverage by up to 90% after flood defenses were strengthened. ⁴ In the United States, property owners receive discounts on flood insurance in increments of 5% for every hazard-reduction point their local government achieves on FEMA's Community Rating System.

With their expertise in risk modeling, risk pricing, and prevention, insurers can help families, businesses, and governments understand and quantify how climate change may be altering the risk to which they are exposed. Signals like premium increases or coverage pullbacks, while feared by property owners, can alert communities to their increasing climate-driven risks and strengthen the business case for investing in climate change adaptation. ⁵

Beyond the traditional insurance markets, however, there is a risk transfer market that vulnerable communities and businesses can utilize—and already are utilizing—to protect themselves from the financial impacts of extreme weather and climate change.

What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency
in the developing world10
in the developing world 10 World Bank leads large-scale risk transfer transactions
in the developing world



Risk transfer for climate change adaptation in the developed world

Contents

	2
What are catastrophe and weather risk transfer contracts?	3
Overview: risk transfer as a tool for climate change adaptation	4
Risk transfer for climate change adaptation in the developed world	5
Large corporations need new tools to assess and manage climate risks	5
Water utilities explore risk transfer to manage costs of weather volatility	7
Transit agencies approach catastrophe and weather risk transfer cautiously	8
Photo and the second second second second	
in the developing world	0
in the developing world	0
Risk transfer to support resiliency in the developing world 1 World Bank leads large-scale risk 1 transfer transactions 1 Farmer-focused weather index insurance 1 to protect the most vulnerable 1	0 1 4
Risk transfer to support resiliency in the developing world 1 World Bank leads large-scale risk transfer transactions 1 Farmer-focused weather index insurance to protect the most vulnerable 1 "Smallsats" and weather data science can enable growth of weather index-insurance 1	0 1 4 6
Risk transfer to support resiliency in the developing world 1 World Bank leads large-scale risk transfer transactions 1 Farmer-focused weather index insurance 1 to protect the most vulnerable 1 "Smallsats" and weather data science 1 can enable growth of weather 1 Private firm aims to protect farmers and 1 Private firm aims to protect farmers and 1	0 1 4 6
Risk transfer to support resiliency in the developing world 1 World Bank leads large-scale risk transfer transactions 1 Farmer-focused weather index insurance 1 to protect the most vulnerable 1 "Smallsats" and weather data science 1 can enable growth of weather 1 Private firm aims to protect farmers and 1 Micro-entrepreneurs from climate change 1	0 1 4 6 8

Large corporations need new tools to assess and manage climate risks

Corporations with public equity or debt are facing pressure from large investors and financial regulators to assess, disclose, and mitigate the risks that climate change presents for their assets and operations—both the "transition risks" presented by evolving polices to lower GHG emissions and the physical risks of damage from changing weather patterns. ⁶ This is a particular focus of ESG investors who seek to evaluate the long-term sustainability of an enterprise based in part on their behavior around environmental, social, and governance factors.

Financial analysts are increasingly highlighting the weather sensitivity of industry sectors such as consumer cyclical, consumer non-cyclical, and industrial. A June 2018 S&P Global report co-authored with Resilience Economics examined public corporate reports for the year ending April 2018 and found that 73 companies in the S&P 500 disclosed effects on earnings from weather; and those quantifying that effect reported an average impact of 6%. Other analyst firms are also noting weather's adverse impacts on corporate earnings: in May 2018, Credit Suisse downgraded Kohl's Corporation's stock in advance of its first quarter earnings call, citing the cold, icy winter and the firm's greater exposure to winter's impacts than its peers due to its concentration of stores in the Northeast and Great Lakes.⁷⁸

Figure 1

Key Takeaways from the S&P Global Ratings and Resilience Economics June 2018 report on the Impact of Weather on Corporate Earnings

In financial 2017, 73 companies (15%) on the S&P 500 publicly disclosed an effect on earnings from weather events, but only 18 companies (4%) quantified the effect.

The average materiality on earnings for the small number of companies that quantified it was a significant 6%.

Climate risk is a surprisingly prevalent topic of discussion for the CEOs of publicly traded companies, and management teams are becoming increasingly accountable for understanding and mitigating the impact of climate risk.

Evidence of the impact of climate risk is found across all sectors, geographies and seasons.



Large corporations need new tools to assess and manage climate risks (continued)

Could weather-risk transfer (WRT) become a mainstream risk hedging tool for such corporations whose performance and earnings are increasingly subject to climate risk? Growing numbers of companies that have never purchased WRT are inquiring about risk transfer alternatives. It seems likely that this trend will continue and WRT will be considered as a tool to mitigate the risks of variable weather by a growing number of large corporations.

Firms that routinely purchase WRT contracts are in highly weather-sensitive industries like electric and gas utilities, renewable power, agriculture, and other sectors. In each of those sectors, there is a clear and often finely tuned understanding of how weather affects earnings. This makes it easier to tailor WRT products to specific needs and to solicit pricing from counterparties. For firms in other industries, it can be more difficult to isolate weather impacts from other factors. For example, a boutique retailer which experiences lower-than-expected sales during an unusually rainy fall may not know how much of that impact was due to weather versus the fact that its fall line didn't appeal to customers.

Figure 2

Examples of Climate-Related Physical Risks and Potential Financial Impacts

Acute	 Reduced revenue from decreased production capacity (e.g.,
 Increased severity of extreme weather events such as cyclones and floods 	 Reduced revenue and higher costs from negative impacts on workforce (e.g., health, safety, absenteeism)
Chronic	 Write-offs and early retirement of existing assets (e.g., damage to property and assets in "high-risk" locations)
 Changes in precipitation patterns and extreme variability in weather patterns 	 Increased operating costs (e.g., inadequate water supply for hydroelectric plants or to cool nuclear and fossil fuel plants) Increased capital costs (e.g., damage to facilities)
 Rising mean temperatures 	 Reduced revenues from lower sales/output
 Rising sea levels 	 Increased insurance premiums and potential for reduced availability of insurance on assets in "high-risk" locations

Source: Task force on Climate-Related Financial Disclosure

Furthermore, there are distinctions between hedging shorter-term seasonal variations in weather and hedging the longer-term risks that climate change presents. Timing of when the most severe impacts of climate change will manifest is highly uncertain, making it difficult to price longer-term risks in a manner equivalent to the existing WRT business.^{9 10}

One way to help to address this problem would be to introduce more of a term structure of protection. In the same way that the cost of borrowing varies from very short- to very long-term credit instruments – a cost curve for climate risk would, like the yield curve for credit risk, provide an important signal to market participants.

At this point, uncertainty over the timing and severity of climate impacts is also shaping the priorities of corporations responding to the Financial Standards Board's recommendations on climate-related financial disclosure (Figures 2 and 3). To date, most have been focusing on transition risks—the potential costs and impacts to their business of new low-carbon mandates and policies—and not physical risks. Institutional investors concerned about climate change risk in their portfolios are taking the same tack. But physical risk has become a growing concern for many investors and corporations. ¹¹

Introduction2
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited



Large corporations need new tools to assess and manage climate risks (continued)

Figure 3

N	on-financial Sectors Most	Likely to Face Climate Ris	ks
Energy	Transportation	Materials and Buildings	Agriculture, Food, and Forest Products
Oil and GasCoalElectric Utilities	 Air Freight Passenger Air Transportation Maritime Transportation Rail Transportation Trucking Services Automobiles and Components 	 Metals and Mining Chemicals Construction Materials Capital Goods Real Estate Management and Development 	 Beverages Agriculture Packaged Foods and Meats Paper and Forest Products
Source: Task Force on Climate Related Fir	ancial Disclosure		

Forward-thinking global corporations—especially those headquartered in Europe and Australia/New Zealand where corporate leadership and regulators are highly attuned to climate change risks—are taking on the challenge of assessing how the physical risks stemming from climate change will impact their assets and revenues.

To some extent, they're relying on a small but growing cluster of consulting and climate risk analytics firms. These include: Acclimatise, CLIMsystems, Climacell, Coastal Risk Consulting, FourTwentySeven, Jupiter, and The Climate Service. Additionally, professional services firms such as DNV GL, AECOM, ICF, and Golder that advise global corporations and governments are integrating climate risks into their services and developing specialized climate risk analytical tools. ¹²

As these analytical tools and services evolve, it is expected they will help enable corporations exposed to climate risks to develop comprehensive adaptation strategies, including strategically transferring some of their weather risks to third-party specialist investors rather than keeping them on their own balance sheets.

Water utilities explore risk transfer to manage costs of weather volatility

Water utilities in many parts of the world are facing weather-related risks linked to climate change, including longer and more severe dry spells and droughts, intrusion of saltwater into coastal aquifers, and growing threats to water quality such as harmful algal blooms—which are appearing in water bodies at higher latitudes than previously observed. At the same time, the water utility sector faces chronic funding challenges to meet current and future infrastructure needs. The US EPA's 2015 survey of drinking water utilities identified capital funding needs of \$473 billion by 2035.¹³

Whether publicly owned or investor-owned, water utilities are already subject to significant cost and revenue impacts from weather variability. Droughts can make expensive alternative supplies necessary and reduce revenue as customers respond to drought restrictions and surcharges. Storms and floods can require utilities to make expensive repairs. ¹⁴

Utilities have financial management tools to deal with these contingencies, such as reserve funds and the ability to increase rates or impose surcharges. In some cases, weather risk transfer (WRT) can provide cost-effective protection against their weather risks.

Contents

Introduction2
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
Risk transfer to support resiliency in the developing world
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change18

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Water utilities explore risk transfer to manage costs of weather volatility (continued)

In a 2014-2015 research project with Western U.S. water utilities that was published in the January 2015 American Water Works Association's Journal, Nephila drew on 10 years of financial and weather data provided by the utilities to analyze how WRT could lessen the impacts of extreme weather on the utilities' finances. In one case, a Colorado utility experienced \$14 million in flood damage after an unusually heavy storm in 2013. The authors structured a hypothetical WRT contract with an index trigger of 22" of total rainfall during the 50 wettest days of the year and a notional payment of \$1.5 million per inch over the trigger, with a \$15 million cap. Had the contract been in place during 2013, the utility would have been paid \$15 million (\$1 million more than their loss); the premium cost for this coverage, when spread across all ratepayers, would have approximated 5% of the average customer's water bill. ¹⁵

One of the more recent WRT transactions in the water utility sector was executed in Australia, a fact that likely reflects that country's historically dry climate, the severity of droughts in the last 20 years, and the increasingly volatile wetdry weather patterns. After enduring multiple cycles of drought followed by floods, a water utility will be more likely to consider WRT because it has learned that it can better manage its weather and climate risks by combining WRT with existing financial tools like risk reserves and rate increases.¹⁶

Transit agencies approach cat and weather risk transfer cautiously

Transit agencies in the U.S. Midwest and Northeast are vulnerable to extreme snowfall and flooding, and have considered using weather risk transfer contracts or catastrophe bonds. Only two transit agencies are known to have executed such transactions: the New York Metropolitan Transit Agency and Amtrak.

When Hurricane Sandy caused between \$4 billion and \$5 billion in damage to the NYMTA's assets in 2012, it was only covered for \$1 billion. After the storm, the NYMTA watched its insurance premiums double. As part of its risk management strategy, the agency issued a three-year \$200 million catastrophe bond in 2013. Catastrophe modeler Risk Management Solutions (RMS) helped it structure the bond with storm surge triggers for different parts of the city—from 8.5 feet in the Battery to 15.5 feet elsewhere. The agency's premium payments were 4.5% annually. No storm surge passed the trigger elevations during the contract period, so no payouts were made. ¹⁷

In May 2017, the NY MTA returned to the catastrophe bond market with a \$125 million catastrophe bond that included protection against earthquakes as well as storms for three years. The notes were priced at 3.7%. ¹⁸

Amtrak's \$275 million catastrophe bond was issued in 2015 for slightly more than three years of protection against storm surges, high winds, and earthquakes. The bond specified seven tidal gauges for storm surge measurements, wind measurements for 60 zip codes along the railroad's Washington, D.C.-Providence, RI corridor, and earthquake intensity at 22 ZIP codes in the same region.¹⁹

WRT contracts can complement natural catastrophe risk transfer products and be used by transit agencies and other local governments to reduce the costs of managing weather impacts that don't reach a disaster threshold. For example, above-average snowfall can negatively impact ridership for transit agencies. In a January 2015 snowstorm, Washington, D.C.'s Metro lost approximately \$7 million in revenue due to decreased ridership as the storm approached and a total loss of revenue after the storm shut down the system. Additional costs were incurred to dig out and inspect unsheltered rail cars and buses.²⁰

Atmospheric and Environmental Research (AER) has developed a snowfall index prototype for transit agencies whose revenues and costs can be negatively impacted in winters with more intense snowstorms than usual. The firm's analysis of historical snowfall data indicates that a weather risk transfer or catastrophe bond structure designed for a transit agency—using a customized index tailored to the agency's weather risk exposure—could result in advantageous risk management for the cedent. Along with AIR Worldwide, AER has presented the concept to transit agencies but, as of this writing, have not executed a transaction. ²¹



Transit agencies approach cat and weather risk transfer cautiously (continued)

One likely barrier to utilization of WRT and cat bonds by transit agencies is lack of experience with these types of products by risk managers. Conducting an analysis of the financial implications of transferring specific weather risks—risks that may be amplified by climate change—for a specific time period at a certain cost may require a level of financial analysis that is lacking in many public sector risk management departments. Additionally, those charged with raising the profile of climate change risks for public agencies—often called Chief Resilience Officers—are typically not empowered to make significant financial decisions. And finally, there's the relentless challenge of tight budgets.²²

A treasury services official at one Northeastern transit agency shared his insights on catastrophe and weather risk transfer anonymously for this report. He and his risk management staff have found little appeal in WRT contracts or cat bonds. They believe their agency is adequately insured, and in the event of an extreme weather disaster, they could expect financial assistance from their state legislature and FEMA. Of course, this simply shifts the cost of risk from the transit agency to taxpayers – this dynamic is discussed at length in the Ceres report, "Inaction on Climate Change" (2013).

Additionally, at conferences and in discussions with risk managers at other agencies, they've heard negative feedback about cat bonds in particular: that the bonds have rarely paid cedents; that due to tax law nuances, cedents can only immediately collect payments equivalent to actual damages; and that cat bonds don't offer any better protection or pricing than traditional insurance. The transit official indicated that he and his counterparts would be more likely to seriously explore cat bonds to hedge their weather risks if municipal credit rating agencies began to downgrade their organizations due to climate and weather risks.²³

Over time, the problem and solution have both changed: five or ten years ago, rating agencies ignored these risks and the data and risk transfer structures were less advanced. In 2019, the agencies and other stakeholders are much more focused on climate risk. Similarly, with the advent of new technology, more robust data and risk transfer structures available in a maturing market, a more responsive risk transfer is now possible with the right partner.

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited



Risk transfer to support resiliency in the developing world

In the developing world, insurance coverage is much less common than in the developed world, especially in the agricultural sector. For more than a decade, development organizations have sought to increase the use of agricultural insurance in the developing world. Insurance, according to the World Bank, can enable poor farmers "to deal with bad events when they do occur, [improve] their welfare in the short run and their opportunities for income growth in the long run." ²⁴

Climate change has increased the urgency to insure poor farmers, especially in Africa, where droughts and heat waves are becoming more severe in many parts of the continent.^{25 26}

Urban dwellers in the developing world are also increasingly at risk. Climate change, population growth, and urbanization (often with poor infrastructure) are conspiring to create a scenario in which 1.3 billion people and \$158 trillion in assets in developing countries could be at risk from river and coastal floods by 2030, according to the World Bank.²⁷

While investment in physical adaptation measures are needed, such as improving stormwater management and coastal defenses, catastrophe and weather risk transfer (WRT) instruments are already becoming part of the adaptation solution through two distinct approaches:



Sovereign (large-scale) programs. These transactions, which often include earthquakes and other non-weather perils, are part of development funders' efforts to support sovereign governments in improving their disaster risk management, which in turn supports a country's financial stability and credit ratings. ²⁸



Farmer-focused (small-scale) programs. A version of crop insurance (sometimes combined with training and support) for farmers to improve their physical and financial resiliency.

Both large- and small-scale programs can be structured using parametric coverage in which payouts are made based on weather or other defined event triggers. Classical indemnity loss coverage requires on-the-ground assessment of losses— something that is infeasible or cost-prohibitive in much of rural Africa, Asia and Latin America. A similar structure often used for agricultural coverage is an area-based yield index: crop yields are measured at reference sites within a region. In this case, payouts to all insured farmers in that region are made when yields at the reference sites drop below a specified trigger.

Just how quickly index-insurance schemes may pay out can be seen in the performance of the Caribbean Catastrophe Risk Insurance Facility (CCRIF). In its 11-year history, CCRIF has paid more than \$136 million to member countries for hurricanes, earthquakes, and excess rainfall—in all cases, within 14 days of the damaging events. Such rapid payouts allow governments and communities to begin rescue, relief, and restoration work sooner than traditional indemnity insurance and donor funding would typically allow.²⁹

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change18

World Bank leads large-scale risk transfer transactions



Large-scale risk transfer contracts in the developing world have been executed both privately and publicly, and often with the support of the World Bank and its affiliates. The bank's first WRT contract was purchased by the Government of Malawi in 2008, after the drought-prone nation suffered a period of low rainfall and resulting food crises. The government and donor countries spent approximately \$400 million in response to 2008 food shortages. ³⁰

To transfer some of the risk of future droughts to investors—and to ensure that emergency funds would be available quickly in future crises—the World Bank and its partners helped Malawi develop a one-year WRT contract using a rainfall index as a proxy for maize production. The bank acted as intermediary between Malawi and investors, and Malawi's premiums were paid by the UK Department of International Development (DfID). Such donations to support risk transfer are common; development partners like DfID would rather pay to transfer these risks than simply increase their financial assistance in every future humanitarian crisis. ³¹

Malawi renewed its weather index insurance contract three years in a row, and since then the World Bank has intermediated or arranged customized risk transfer protection—in the form of cat bonds and WRT contracts—with dozens of other countries or groups of countries (Figure 4).

Each transaction was developed in collaboration with sovereign governments and tailored to secure protection against risks of greatest concern to the respective countries. In one case—the \$450 million risk transaction for Uruguay's national hydropower utility—an oil price index trigger was included along with a rainfall trigger to reflect the reality that the utility's costs to secure electricity during periods of water scarcity would depend on oil prices.

For the World Bank and its member countries, such risk transactions are one aspect of multi-faceted strategies to increase resilience to sudden shocks such as hurricanes and earthquakes and to slower-moving stressors such as drought and water scarcity. The bank views risk transfer as an important element in comprehensive risk management strategies. 32

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited



Figure 4

World Bank Risk Transactions

through February 2018

Catastrophe bonds

Country/region	Transaction type	World Bank role	Amount (USD million)
Pacific Alliance: Chile, Colombia, Mexico, Peru	Natural catastrophe - earthquake (2018)	Intermediation (bond)	\$1,360
Mexico	Natural catastrophe - earthquake & hurricane (2009 and 2012)	Arranger (bond)	\$605
Global	Pandemic (2017)	Intermediation (bond/swap)	\$425
Mexico	Natural catastrophe - earthquake & hurricane (2017)	Intermediation (bond)	\$360
Pacific Catastrophe Risk Financing Initiative	Natural catastrophe - earthquake, hurricane & tsunami (annually, 2012 to 2016)	Intermediation (swap)	\$232.5
Philippines	Natural catastrophe - earthquake & hurricane (2017 and 2018)	Intermediation (swap)	\$595
Caribbean Catastrophe Risk Insurance Facility	Natural catastrophe - earthquake & hurricane (annually, 2007 to 2013, 2014 for 3 years)	Intermediation (swap/bond)	\$203.5
Total			\$3,781

Weather risk transfer

Country	Transaction type	World Bank role	Amount (USD million)
Uruguay	Weather & commodity hybrid - drought & oil price (2013)	Intermediation (swap)	\$450
Malawi	Weather - drought (annually, 2008 to 2011)	Intermediation (swap)	\$19
Total			\$469

Introduction2
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance16
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited



World Bank leads large-scale risk transfer transactions (continued)

African Risk Capacity combines disaster planning with index insurance

One major multilateral weather index insurance program in Africa—the African Risk Capacity initiative (ARC)—combines weather index insurance with training to build the capacity of member countries to use weather index insurance and respond to weather disasters. Managed by the African Union, and funded by bi- and multi-lateral donors and banks, the ARC includes a division that helps government staff at its member countries quantify and model their nation's drought risks; this is a pre-requisite for participating in the ARC's insurance pool. ARC's trainers also seek to ensure that the government is ready to link any ARC payouts "to time-sensitive, livelihood-saving, and cost-effective operations plans." ³³

By requiring these operations plans, ARC helps ensure that its member governments can effectively address the hazards and human impacts that tend to cascade down on vulnerable populations during droughts and heat waves. For example, along with mitigating malnutrition and heat stress, a strong operations plan will also include measures to keep livestock alive until rains resume. ³⁴

Issues and challenges for large-scale risk transfer



Despite growth in the use of catastrophe bonds and other large-scale risk transfer contracts by developing country governments, there has yet to emerge a steady, ongoing demand for these forms of insurance coverage. World Bank staff and professionals in the risk transfer business report several reasons for this:

- **Technical and financial complexity**. Buying tens or hundreds of millions in coverage for weather disasters or earthquakes is inherently a very complex endeavor, and many countries lack the capabilities to accurately model and price their disaster risks. In most cases, donor support is necessary.
- **Political risk**. It can be politically risky for finance ministers in poor countries to purchase large-scale disaster risk transfer contracts (protecting against events that are unlikely to happen in any single specific year) while public budgets remain inadequate to fund existing infrastructure needs and social services. Even after successful transactions, it has been the case that a new administration chooses not to continue risk management practices from previous years.
- **High transaction costs**. Executing a large-scale risk transfer contract with a developing country typically requires years of technical assistance, discussion, and negotiation. The insurers, investors, and others that have participated in these transactions have been motivated to some degree by corporate social responsibility goals. Yet, as private firms, they must ultimately look to the bottom line and prioritize transactions that don't require such extensive staff time and travel costs. If risk transfer is to play a larger role in sovereign disaster risk management and climate change adaptation, the market must become more efficient and less time-consuming.³⁵
- **Insufficient weather data**. Although this is becoming less of an issue globally with technology advancements, basic weather services are lacking in parts of the developing world; in some regions of Africa, only airports have fully functioning weather radar stations. ³⁶ Before the World Bank could execute its first WRT contract with Malawi, it spent three years supporting the creation of weather stations needed to enable the weather-index transaction. In Uruguay, the bank had to establish nine new "witness" stations to verify rainfall readings provided by the government—which, as the cedent that would receive any payouts for low rainfall, couldn't be considered a neutral third-party. ³⁷

Pathways forward for large-scale risk transfer

The challenge of insufficient weather data, while formidable, is being transcended thanks to advances in weather data monitoring and forecasting technology. **See page 16**.

As discussed in the section above (Large corporations need new tools to assess and manage climate risks), experts in the risk transfer space say that what is needed to transfer weather and climate risks more efficiently and equitably from developing nations to insurers and investors is more sophisticated analyses of these risks and their financial impacts. To some extent they're looking to the emerging climate risk analytics firms mentioned on page 7 to provide these analyses.

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
Risk transfer to support resiliency in the developing world 10 World Bank leads large-scale risk transfer transactions 11
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change18



Farmer-focused weather index insurance to protect the most vulnerable

As farmers in the global south are increasingly impacted by climate change, weather risk transfer (WRT) insurance can play an important role in adaptation—especially for the smallest farmers with the least capital and poorest credit standing. According to the Global Alliance for Climate-Smart Agriculture, "in the event of crop damage due to climatic stresses, weather-based crop insurance can assure farmers of some income to mitigate their losses and build resilience." In a drought or other weather disaster, insurance payouts can make it possible for farmers to remain on their land, retain their livestock and other assets and continue investing and even borrowing to fund the next season's planting. ³⁸

The Global Index Insurance Fund, a multi-donor trust fund, has supported partners in covering more than 600,000 farmers, and micro-entrepreneurs with \$119 million in coverage. ³⁹ The oldest and largest weather index-based insurance program began in India in 2003 in Andhra Pradesh. It was followed by the nationwide Weather-Based Crop Insurance Scheme (WBCIS) in 2007. By 2014, almost 14 million farmers were covered based on weather parameters such as dry spells, rainfall, and temperatures. WBCIS is linked to farm loans and is mandatory for borrowers. ⁴⁰

In Sub-Saharan Africa, two of the leading programs offering insurance directly to farmers are Agriculture and Climate Risk Enterprise (ACRE) Africa, supported by the Syngenta Foundation, the Global Index Insurance Facility and others; and the R4 Resilience Initiative founded by the World Food Programme and Oxfam.

ACRE Africa works with networks of local vendors and lenders to bundle insurance with other services that farmers need, such as seeds, fertilizer, equipment and loans. In addition to providing indexed weather coverage, ACRE insurance covers accidental death of livestock. As of 2016, ACRE had reached 1.2 million clients and provided \$56 million in insurance coverage in Kenya, Tanzania and Rwanda. Evaluations published in 2016 indicate that farmers insured through ACRE invested 19% more and earned 16% more than uninsured farmers.⁴¹

Figure 5 The R4 Rural Resilience Initiative

US\$ 2.4 million

distributed in pay-outs to R4 participants in Ethiopia, Kenya, Malawi, Senegal and Zambia since 2011 as compensation for weather-related losses

US\$ 6.6 million

provided in micro-insurance protection to R4 participants in 2017

57,000

farmers (about 300,000 people) reached in five countries as of early 2018

The R4 Rural Resilience Initiative also built its program in collaboration with local groups, including farm associations, governments and lenders. R4 stands for Risk Reduction (asset creation), Risk Reserves (savings), Risk Transfer (insurance) and Risk Taking (borrowing). In service of these principles, R4 promotes physical adaptation measures, such as building stone retaining walls and ponds to capture rainfall, as well as implementing disaster risk reduction training and programs to encourage savings. Currently established in Ethiopia, Senegal, Malawi and Zambia, R4 is being piloted in Kenya and Zimbabwe. Since 2011, it has provided \$6.6 million in insurance protection and paid out \$2.4 million as compensation for weather-related losses. (See Figure 5.) ⁴²

Wholly private enterprises are also offering risk transfer to support resiliency in developing countries: for one example, we look at WorldCover on page 16 in this report.

Contents

Introduction2
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14
Risk transfer to support resiliency in the developing world 10 World Bank leads large-scale risk transfer transactions 11 Farmer-focused weather index insurance to protect the most vulnerable 14 "Smallsats" and weather data science can enable growth of weather 16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and11
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Risk transfer to support resiliency in the developing world10World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change 16Additional findings and conclusions18

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Farmer-focused weather index insurance to protect the most vulnerable (continued)

Issues and challenges for farmer-focused risk transfer

Risk transfer is a foreign concept for small farmers. Farmer-focused index insurance initiatives have to overcome skepticism from small farmers who are focused on day-to-day survival and find the notion of paying for protection against future risks odd in the extreme. Medium-sized and large farmers are usually more sophisticated about risk transfer, and many are already buying insurance commercially. ⁴³

Ongoing subsidies still required. In most farmer-focused index insurance initiatives, extensive premium subsidies are offered to induce farmers to participate. India's WBCIS subsidizes 50% to 70% of premium costs. ⁴⁴

Basis risk can leave farmers short. Basis risk is the difference between what an adverse event actually costs an insured party and what that party receives in compensation. Although weather-index insurance is designed to mimic the loss experience of farmers—i.e., rainfall in a given period that is X% below normal is associated with Y% average lower crop yields—farmers' actual losses might be more or less than their compensation from a weather-index insurance program, leading to confusion and potentially a lack of willingness to continue participating.⁴⁵

Sparse weather stations. As described on page 13, parts of the developing world lack robust networks of weather data stations. In many parts of Africa, there are few trained professionals to operate weather radar stations. National meteorological services in some countries lack the will or capability to share weather data with neighboring countries, and some countries are challenged to reconcile their weather data standards with those of the World Meteorological Organization. This impedes development and growth of weather index insurance for farmers.⁴⁶

Pathways forward for farmer-focused risk transfer programs

Satellite technology and weather analytics are steadily advancing to fill the gaps in weather-station data in rural Africa (see page 16). Additionally, development groups are funding the upgrade of weather forecasting and reporting systems in some regions. The Green Climate Fund's July 2018 grant of \$25 million to strengthen weather and climate data systems in Burkina Faso is one example in Africa. There are also entrepreneurial efforts such as the Ignitia Tropical Weather Forecasting service established in Ghana and Nigeria and WorldCover (see profile on page 16) which uses satellite technology and proprietary analytics to obviate the need for local weather stations. ^{47 48}

To reduce the need for subsidies, proponents of risk transfer for small farmers are seeking **support from vendors of seeds**, **fertilizer and other farm inputs**—businesses that could see a net positive benefit if both current and potential customers become more financially resilient. In Bangladesh, a domestic private insurance company and a seed company are working together to pilot this approach. ⁴⁹ In other countries such as Vietnam, this is already an established business model; commodity traders provide seeds, inputs, and even insurance to farmers through their associations, in exchange for crops at a contracted price. One strategy of the Private Investment for Enhanced Resilience (PIER) program is to work with these traders to provide weather risk transfer so that farmers receive more reliable income despite weather and climate volatility. ⁵⁰ Additionally, at least one wholly private unsubsidized firm, WorldCover, is achieving early success selling weather-index insurance to African farmers.

Reducing basis risk is a complex challenge. Some insurance schemes are integrating area-based yield indexes with weather indexes to better reflect actual yield. The authors of the Climate-Smart Agriculture report credit the R4 project with innovation in minimizing basis risk by using multiple data sources for its event triggers. Furthermore, the R4 project encourages farmers to accrue savings that can be tapped to supplement insurance payouts after poor harvests. ⁵¹

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world5
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency
In the developing world 10
World Bank leads large-scale risk transfer transactions
World Bank leads large-scale risk transfer transactions11Farmer-focused weather index insurance to protect the most vulnerable14"Smallsats" and weather data science can enable growth of weather index-insurance16Private firm aims to protect farmers and micro-entrepreneurs from climate change 1618

"Smallsats" and advances in weather data science can enable growth of weather index-insurance

The lack of robust weather data networks in rural Africa has impeded growth of weather-index crop insurance that can protect farmers from the impacts of drought. While development groups look to fund networks of weather stations in areas that now lack them, satellites, other types of remote sensing technology, and weather data science and analytics services are evolving rapidly and will likely fill many of the gaps that now hamper the growth of weather-index insurance.

As described below, the private firm WorldCover has been able to combine external satellite weather data with proprietary weather and agronomic models to sell weather-index insurance to tens of thousands of farmers in regions of Ghana, Kenya and Uganda that currently lack weather stations. And satellites aren't the only data acquisition platform driving growth of available weather data. ClimaCell uses wireless networks, weather radar, and satellite data to deliver highly granular weather data. Orbital Insight scoops up and analyzes data from satellites, unmanned aerial vehicles and other geospatial data sources.

With financial and launch support from China, Ethiopia's Space Science and Technology Institute will use data from its first satellite (scheduled for launch later in 2019) to monitor climate change and other environmental issues, as well as to expand weather-index insurance for farmers. A spokesman for Ethiopian insurance firm Oromia said the company expects the satellite to facilitate weather-index insurance for farmers by providing high-resolution weather data at lower costs than its current source, a U.S.-owned satellite. ⁵²

Increasingly robust weather data for rural Africa will become available as the remote sensing industry grows. Some weather data providers, including Orbital Insight, view weather-index insurance in the developing world as a target market. Others have announced initiatives to improve weather monitoring and forecasting in the developing world. ClimaCell, for example, will use some of the \$45 million in venture capital it secured in fall 2018 to expand into "places that have little to no weather forecasting infrastructure, like much of the developing world," according to its news release.

WorldCover: private firm aims to protect farmers and micro-entrepreneurs from climate change

Most risk transfer initiatives for farmers in developing countries have been created by NGOs with support from governments, foundations, and other development funders. These initiatives sometimes partner with private investors to obtain risk capital and with private brokers to sell insurance, but they still rely on continuing subsidies. This is seen as a potential weakness and impediment to growth.

The risk transfer firm, WorldCover, is working to prove a private business model in three African countries, seeking to insure farmers in developing countries without relying on subsidies.

CEO Christopher Sheehan founded WorldCover as a Delaware public benefit corporation (a private for-profit corporation that balances public-benefit purposes with profit) in 2015. Sheehan was looking for a way to leverage his previous hedge fund experience and skill set for social impact when a conversation with Yale development economist Christopher Udry steered him toward risk transfer. "Professor Udry highlighted the degree to which risk was impeding development," recalled Sheehan. "Even with all the innovative lending programs and microfinance institutions, many businesses, particularly in agriculture, still couldn't borrow money because their risks were unacceptably high."

After winning seed funding from the venture incubator Y Combinator and other investors, WorldCover conducted extensive market testing in Ghana. "We figured out what the pain points were for buyers, the satisfaction points, the factors in their renewal decisions," said Sheehan. "Then back home we developed our own proprietary weather models and agronomic models to match weather variables to the yields that farmers are actually getting."

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited



WorldCover: private firm aims to protect farmers and micro-entrepreneurs from climate change (continued)

Sheehan approached Barney Schauble, chairman of Nephila Climate, about providing risk capital (reinsurance) for the insurance that WorldCover would originate. "Nephila understood right away the potential of what we were doing, and agreed to support us with early risk capital, much as they did with Silicon Valley startup WeatherBill, also known as The Climate Corporation," said Sheehan. (Founded in 2006 to provide weather risk transfer contracts online for a variety of North American industries, The Climate Corporation shifted to focus exclusively on U.S. agriculture in 2010; in was purchased by Monsanto in 2013.)

WorldCover's weather and agronomic models allow real-time customized structuring of coverage that takes into account a farmer's location, crop and even planting schedules, according to Sheehan. And the weather index data—the key metric in parametric weather risk transfer, and something that is scarce in much of rural Africa—is measured by satellites at reference locations in farming areas.

Sheehan says WorldCover communicates its business model in a transparent manner that gives customers confidence. "We convey that since there aren't local weather stations, we're going to point satellites at their community center and pay them a fixed amount when drought affects that location," said Sheehan. "That transparency and simplicity" facilitates the sale and—Sheehan says—has led to high levels of satisfaction and renewals.

Like ACRE Africa, R4 and other weather risk transfer initiatives in Africa, WorldCover takes advantage of the widespread use of mobile phones in Africa to market its products, and to receive and make payments.

To date, WorldCover has sold drought insurance to tens of thousands of farmers across West and East Africa. Sheehan expects the firm to expand soon to other regions and to start offering weather insurance to micro-businesses outside the agricultural sector.

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency
in the developing world 10
in the developing world

Additional findings and conclusions

Classical insurance and reinsurance markets have been augmented and extended by the creative introduction of investor capital to address shortfalls in risk capacity. This paper sketches a mixed portrait of the viability of catastrophe and weather-risk transfer (WRT) for climate change adaptation, but some additional benefits of this type of coverage should be mentioned.

Both WRT and cat coverage can help public and private sector organizations understand the economic value attached to their risks from weather by providing price signals. Just as a London electric utility has used the WRT market to put a value on variations in temperature driving winter heating degree days demand, so can a retailer use WRT to better understand the costs of a severe winter; and a municipality on the Atlantic coast can get a better handle on the value of assets at risk the next time a hurricane coincides with a king tide, as occurred with Hurricane Sandy. Parametric index-based WRT can provide better pricing information than traditional property and casualty insurance because the process of setting the index trigger requires the parties to develop a fuller understanding of their risks. ⁵³

WRT contracts, especially those with longer terms, can provide transitional risk protection while public and private sector cedents design and implement more comprehensive adaptation measures. Improving physical resilience for a coastal city, for example, will require enormous investments over long periods of time. For a large corporation with global assets and supply chains, business relocation and process re-engineering will require protracted planning and funding cycles. While untested at this time, it is plausible that WRT can be used to mitigate climate risks until infrastructure and business structures are made more resilient.

Finally, the existing weather and catastrophe risk transfer markets have developed over many years, with firms such as Nephila assisting cedents to design and price weather hedges and catastrophe risks. The market has matured over 25 years, with cedents and their investor counterparties trading tens of billions of dollars in weather and catastrophe risks annually. Yet, outside of this market (including a small subset of financial managers), there is still limited awareness of what a WRT contract or catastrophe instrument is and why it has such important value.

As climate change drives more interest in mitigating and hedging growing risk exposure, and as word gets out how industries like electric power, agriculture, and renewable energy have hedged weather risks in a productive way for over a decade, it is a reasonable hope and expectation that WRT and catastrophe coverage can be successfully and cost-effectively used for climate change adaptation by a wide range of public and private organizations.

Introduction2
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions



Additional findings and conclusions (continued)

Figure 6 Sample term sheet – Water Utility



MM DD, YYYY

This financial product protects the water service provider against low revenue resulting from low water consumption. The seller shall compensate the buyer when actual water use is below the service provider's minimum required water use.

Indicative Term Sheet (Confidential)

Product	Low Water Use Protect	ion		
Protection Seller	[•]			
Protection Buyer	[•]			
Term	Water Year			
Start Date	Oct 1, YYYY			
End Date	Sep 30, YYYY			
Settlement Frequency	Quarterly			
Settlement Data Provider	Protection Buyer			
Settlement Data Verification Agent	[Independent 3rd Party]			
Measurement Variable	Water use (units: megal	itres)		
Location	[•] (insert list of region	s within water service	e provider's service foot	print where water
	use will be measured)			
		Minimum	Notional Payment	Quarterly
		Required Water	(\$/ML)	Maximum
		Use (ML)		Payment (\$)
	Quarter 1	[•]	[•]	[•]
	Quarter 2	[•]	[•]	[•]
	Quarter 3	[•]	[•]	<mark>[•]</mark>
	Quarter 4	[•]	[•]	[•]
Quarterly Minimum Required	10% (relative to 10-year	r average historical w	ater use)	
Water Use Percentile				
	Minimum Required Wa	ter Use is the amount	of water use the buyer	requires to balance
	its budget. The values in	n the table above are	ower than 9 out of 10 or	f the most recent 10
	years of water use. This	protects the buyer ag	ainst what it considers a	a relatively remote
	yet possible negative fir	nancial outcome.		
Actual Quarterly Water Use (AQWU)	AQWU = Total Meast	ured Water Use du	r <i>ing Quarter</i> (megalitr	res)
Quarterly Payment (QP)	QP =	Notional Payment	$\times (MMRWU - AQWU)$	J)
	If actual water use is be	low the minimum rec	uired water use, then Pr	otection Seller
	pays Protection Buyer a	in amount equal to QI	P. QP shall not exceed the	ne Quarterly
	Maximum Payment (QI	MP).		
Annual Payment (AP)		$AP = Sum \ of \ Qua$	rterly Payments	
	ICAD: 1	4 D		
	If AP is greater than zer	o, then Protection Se	lier pays Protection Buy	er an amount equal
	to AP. AP shall not exc	eed the Annual Maxin	num Payment (AMP).	
Annual Maximum Payment (AMP)	(maximum payoff to	b Buyer that is possib	le during the Term)	
			- (1-11)	

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Introduction2	
What are catastrophe and weather risk transfer contracts?	
Overview: risk transfer as a tool for climate change adaptation4	
Risk transfer for climate change adaptation in the developed world	
Large corporations need new tools to assess and manage climate risks5	
Water utilities explore risk transfer to manage costs of weather volatility7	
Transit agencies approach catastrophe and weather risk transfer cautiously8	
Risk transfer to support resiliency in the developing world10	
World Bank leads large-scale risk transfer transactions11	
Farmer-focused weather index insurance to protect the most vulnerable	
"Smallsats" and weather data science can enable growth of weather index-insurance16	
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16	
Additional findings and conclusions	
Sources cited	



Additional findings and conclusions (continued)

The term sheet on page 19 is a representative example of financial transactions executed within the weather risk transfer market. We highlight the water services sector for a few reasons:

- Protection buyers like water service providers can be publicly or privately owned.
- The sector highlights the continued expansion of weather risk transfer beyond the traditional sectors of energy and agriculture.

The sector has demonstrated preference for weather-linked indexes, such as water consumption. This highlights the expansion of product offerings beyond explicit weather indexes like rainfall. The term sheet includes attributes that are defined explicitly in any contract:

- The basic purpose is to provide for payment if water usage falls below defined minimum levels in any quarter or year, to replace lost revenue.
- Term: the duration of protection, which typically spans from multiple months to multiple years.
- Underlying index: the weather-driven metric that links to the protection buyer's operational and financial performance. In this case of water usage.
- Location: the specific geography where the index is measured.
- Financial payment: the compensation per index value, up to a maximum payment amount.

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world
World Bank leads large-scale risk transfer transactions
World Bank leads large-scale risk transfer transactions
World Bank leads large-scale risk transfer transactions
World Bank leads large-scale risk transfer transactions
World Bank leads large-scale risk transfer transactions

Sources cited:

Contents

nephila climate

	Introduction
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Page 21 of 23

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Page 22 of 23

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited



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Contents

Introduction
What are catastrophe and weather risk transfer contracts?
Overview: risk transfer as a tool for climate change adaptation4
Risk transfer for climate change adaptation in the developed world
Large corporations need new tools to assess and manage climate risks5
Water utilities explore risk transfer to manage costs of weather volatility7
Transit agencies approach catastrophe and weather risk transfer cautiously8
Risk transfer to support resiliency in the developing world10
World Bank leads large-scale risk transfer transactions11
Farmer-focused weather index insurance to protect the most vulnerable
"Smallsats" and weather data science can enable growth of weather index-insurance
Private firm aims to protect farmers and micro-entrepreneurs from climate change 16
Additional findings and conclusions
Sources cited

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