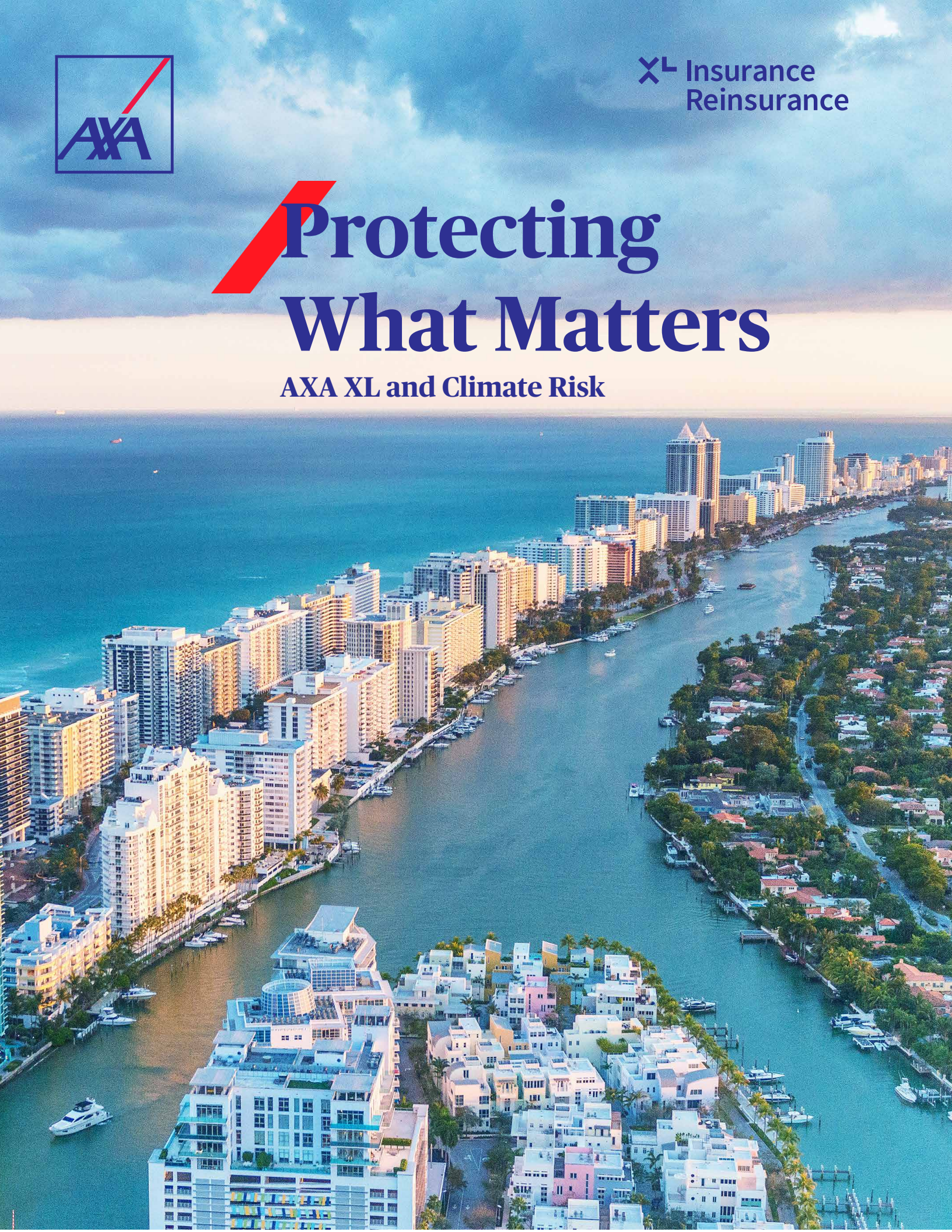


AXA

XL Insurance Reinsurance

Protecting What Matters

AXA XL and Climate Risk

Protecting what matters

Click to go to any section or article

AXA XL is the Property & Casualty and Specialty division of AXA Group: providing products and services through three business groups: AXA XL Insurance, AXA XL Reinsurance and AXA XL Risk Consulting.

AXA XL and Climate Risk: Protecting What Matters

A continuously changing world creates new risks, and AXA XL has been working hard to quantify these emerging risks, and to provide robust and innovative solutions.

We live in a world where the one constant is that things are continuously changing. It is human nature to push the boundaries in all aspects of existence and with that comes risk. Climate risk impacts a large number of lines of business that we write at AXA XL. Given AXA's purpose: A*cting for human progress by protecting what matters*; we want to showcase the multifaceted work being done at AXA XL by diving into the climate risk equation, looking at market resilience through innovation and the role that insurance has to play now and in the future, to assess climate risk and address the associated challenges and opportunities.

A continuously changing world creates new risks, and AXA XL has been working hard to quantify these emerging risks, and to provide robust and innovative solutions. We consider climate risk to be a function of the hazard, exposure and vulnerability, and touch upon each of these elements within the different sections of this report. We also delve into some of the potential impacts of climate change on climate risk, and how AXA XL is provisioning resources to evaluate the range of possible scenarios. Research is a key part of the work we carry out to drive innovation, and we are actively working on several projects which challenge our thinking around the perils to which we are exposed. Innovation does not always have to be in relation to a product, and we highlight here some of the creative thinking around the hazard part of the risk equation. Exposure and vulnerability changes are paramount to understanding climate risk, both now and in the short-term future, and we showcase examples of the work being done in this area as we aim to improve the data we collect from clients in order to understand the exposure and vulnerability part of the risks we write in more detail.

For the world to thrive amidst continuous change, we must enable resilience and adaptation. Insurance is a key part of the resilience framework and we highlight this through a recent study completed with the Cambridge Centre for Risk Studies on the topic of Disaster Recovery and the important role that insurance plays in recovery post a catastrophic event. Public Sector Partnerships and parametric insurance solutions are

It is crucial that we adequately manage exposure to climate risk if we are to continue playing our part in advancing human progress

initiatives being led by AXA XL to expand our capabilities in these spaces. From involvement in the Arctic and Seaview Surveys to exploratory work in the deep ocean, AXA XL has always shown a profound interest in the natural environment. We have been a leading partner on the Coastal Risk Index which is a project that further exemplifies our commitment to the natural environment. Alongside this work we continue to investigate the importance of natural assets like mangroves, seagrasses and coral reefs in protecting and providing resilience to coastal communities, whilst also being large sequesters of carbon.

Corporate Social Responsibility (CSR) is an integral part of the way we transact business at AXA XL, with Climate and Water being key pillars of our CSR strategy. Here we highlight some of the core CSR initiatives at AXA XL and, more importantly, how they link back to the business. We achieve this through the evolution of community-based initiatives aimed at creating resilience whilst also acting as an incubator for insurance related products.

Under our new purpose, it is crucial that we adequately manage our exposure to climate risk if we are to provide the protection necessary to advance human progress. The work detailed in this brochure shows how seriously we take this purpose as we strive to understand climate risk more clearly, whilst also developing innovative ways to transfer this risk and ensuring the resilience of the communities that we protect.

We hope you will find this report an interesting introduction to the diversity of works being carried out at AXA XL to improve our understanding and put us at the leading edge of climate risk. AXA XL contacts are included in each of the sections should you wish to learn more.

Jonathan Gale
Chief Underwriting Officer, Bermuda Reinsurance, AXA XL

Andrew MacFarlane
Bermuda and London Head of Reinsurance Pricing and Analytics, Reinsurance, AXA XL

About the Authors:

Jonathan Gale is AXA XL's Chief Underwriting Officer, Reinsurance. In this role he is responsible for delivering underwriting excellence, underwriting portfolio management, customer relationship management, developing new business opportunities and further demonstrating AXA XL's thought leadership capabilities. He is particularly interested in Climate Risk; the role re/insurance plays in disaster recovery (speed and quality of recovery); the growing gap between economic loss and insured loss; and the complementary potential of private re/insurance and governments. Jonathan is based in the UK and can be contacted at jonathan.gale@axaxl.com.

Andrew MacFarlane has a BSc. Hons Actuarial Science & Statistics and FIA. He is Head of Pricing & Analytics for London & Bermuda for Reinsurance at AXA XL and a Partner on AXA XL's Leadership Council. In his Head of Pricing & Analytics role he manages the actuarial team across London and Bermuda supporting underwriters across a broad range of business lines and products. Andrew was involved in setting AXA XL's CSR strategy and is a member of the AXA XL CSR Steering Group. Andrew plays an instrumental role in looking to expand AXA XL's involvement in closing the protection gap and leads the Public Sector Partnership practice group at AXA XL. The aim of the group is to strengthen partnerships with the public sector in order to bring socially impactful insurance solutions to the market. Andy is based in Bermuda and can be contacted at andrew.macfarlane@axaxl.com.

Climate Risk

Articles defining the climate risk equation, the risks associated with climate change and what we are doing to better understand clients' exposure

Understanding the Climate Risk Equation

The Risks Associated with Climate Change

Natural Perils: Tropical Cyclones, Extra-tropical Cyclones and Wildfire

The Importance of Exposure Modelling

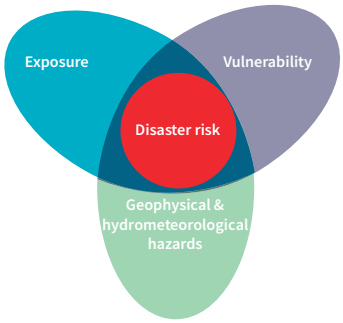
Understanding the Climate Risk Equation

Risk is defined as (n): a situation involving exposure to danger.

When we as an industry talk about risk, we think about it in the context of the following equation:

Risk = ƒ(Hazard, Exposure, Vulnerability)

We need to clearly define what we mean by each component and contemplate the complicated non-linear relationship that exists between these components to understand risk now and in the future.



When we talk about Hazard, we are referring to the peril or event that has the capacity to damage or destroy a particular asset. The peril here could be tropical cyclone, wildfire, earthquake, or flood, to name a few.

Exposure is defined as the amount of an asset that is exposed to the hazard in a given space and time. This refers to the properties, vehicles or other assets that form part of a portfolio of assets

Continued ➲

By Andrew MacFarlane

that we (re)insure. A key aspect of exposure is the numerous characteristics relating to the particular asset that are important to understand in order to try to model the interactions that exist between the hazard and vulnerability. Some examples of these might be: method of construction, materials used, roof types, roof geometry, deck construction and materials. These building attributes are all important aspects of exposure that allow a more holistic picture of the risk to be modelled.

Vulnerability is defined as the susceptibility or damageability of an asset to a given intensity of the hazard. The extent to which an asset is vulnerable to a hazard is also intricately linked to the characteristics of the asset (as mentioned above), further highlighting the importance of capturing and understanding all key aspects related to the exposure in order to accurately estimate vulnerability to assess the risk.

The relationship between these 3 variables is non-linear, it is also not additive or multiplicative, rather it is a complicated interaction that is non-stationary and is evolving over time. Risk modelling will continue to gain importance, within and outside the industry, as we seek to understand how assets are likely to be impacted in a changing climate. It is for these reasons that we need to ensure that we communicate clearly within the industry and beyond how we think about risk and ensure that this definition is used consistently.

Having a clear definition of how we model risk is key when we discuss the risks and opportunities we face as a (re)insurer when it comes to climate change. Frequently in discussions around a changing climate we see the word Risk used where Hazard is more relevant. The importance of getting this right is to ensure that when focusing on risk we face as a (re)insurer we are understanding and investigating all aspects of the risk equation and not just focusing on the hazard. Focusing on one aspect of the risk equation and neglecting the others gives an incomplete picture of how risk is going to change in the future.

Understanding how each component changes along with how the relationship between all three components change allows us to get a clear picture of how Risk is going to evolve.

A changing climate is going to impact the hazard, both positively and negatively, and over the timeframes that hazard changes emerge there will equally be changes in both underlying exposures and vulnerabilities. Understanding how each component changes along with how the relationship between all three components change allows us to get a clearer picture of how Risk is going to evolve.

By defining risk this way, we are also able to effectively discuss the societal risks that we are facing from a changing climate. Population growth is a key driver of exposure growth, along with urbanization and the accumulation of assets in areas exposed to hazards. Whilst these are big drivers in increasing risk, we know technological advances will help communities improve their adaptability and become more resilient to the hazards they are likely to face in the future which will hopefully reduce the risk they face over time.

Risk is a complicated problem, but we as (re)insurance professionals are best placed to understand and communicate what Risk is and how the key components can potentially interact in the future.

About the Author

Andrew MacFarlane has a BSc. Hons Actuarial Science & Statistics and FIA. He is Head of Pricing & Analytics for London & Bermuda for Reinsurance at AXA XL and a Partner on AXA XL's Leadership Council. In his Head of Pricing & Analytics role he manages the actuarial team across London and Bermuda supporting underwriters across a broad range of business lines and products. Andrew was involved in setting AXA XL's CSR strategy and is a member of the AXA XL CSR Steering Group. Andrew plays an instrumental role in looking to expand AXA XL's involvement in closing the protection gap and leads the Public Sector Partnership practice group at AXA XL. The aim of the group is to strengthen partnerships with the public sector in order to bring socially impactful insurance solutions to the market. Andy is based in Bermuda and can be contacted at andrew.macfarlane@axaxl.com.

The Risks Associated with Climate Change

Physical Risks Associated with Climate Change

There is no dispute that the climate is changing. Greenhouse gas emissions are at the highest levels seen for millennia. These changes are affecting multiple areas of our climate system; namely sea-levels, the atmosphere, the oceans, the cryosphere and carbon and other biogeochemical processes. However, the impacts of these changes on the risks and the opportunities we are exposed to as an industry are complex and represent a serious challenge to accurately constrain.

As mentioned previously, as an industry, we think about risk as a function of hazard, exposure and vulnerability. A common misconception is that the year-on-year changes in losses we see are driven purely from the hazard. This is not the case: the changes are a function of all these components. The science is clear that the hazard is changing for different climate-related perils, but the direction and order of magnitude of these changes is usually slow and, in many instances, highly uncertain. There also tends to be a one-way narrative about the increases in risk from climate change when, in fact, there will be instances where we will see risk (through combination of hazard, exposure and vulnerability) decrease. Understanding when and where these changes are likely to occur present opportunities for our industry.

Where we do have climate projections of the expected change in hazard, these are mostly at time scales that are at a time horizon too far away and a resolution too coarse in terms of how we think about managing our business. Climate Projections most often exist out to 2050 or 2100 at coarse resolutions making inferences about ocean basins or large areas of land. When looking at our underwriting, business and capital planning we are most interested in a short-term view of around 3-5 years and need high resolution modelling to allow us to understand the impact that these changes in the hazard will have on the risks that we face.

Continued ➲

By Andrew MacFarlane – Physical Risk
Katie Lennon – Transition, Liability Risk

The complicated relationship that exists between the components of the risk equation means it is not clear how risk will change in the future.

With this insight, it is therefore critical that we look to understand comprehensively the factors contributing to the risk from climate-driven perils. Recent work we have carried out suggests that the biggest driver of changes in losses in the past 10 years has come from changes in exposure. These changes have been generated by increases in property values, economic growth and population dynamics, among other things. We have strong confidence that these exposure factors will continue to change and be key drivers in changes in risk in the near-term. Focusing on exposure over this timeframe will also more easily allows us to constrain the hazard impacts that we may see in a changing climate. Similarly, the vulnerability or resilience of a community in a specific region from a certain peril will likely see changes as communities adapt to become more resilient to natural perils through the implementation of climate defences and/or more robust building codes and restrictions. It is clear that focusing on the three components of the risk equation is essential when trying to understand the impact that a changing climate has on the risk we face as an industry.

As an industry we are exposed to less frequent but more severe losses driven by extremes in the weather. We need to understand the difference between weather and climate. Climate encompasses broad scale averages either in space or time or both space and time, whilst weather refers to short-term, relatively regional events. When discussing the impacts of climate change for the industry, it is important to distinguish between weather and climate because weather is most often a more complex and chaotic variable to understand. This requirement to focus on weather leads to increased uncertainty when trying to assess the impact of climate change but, somewhat unfortunately, it is these short-term relatively regional weather events that most impact the industry.

The science in many instances is clear in terms of the long-term direction relating to certain climate phenomena, such as global average surface temperature, that changes in the climate will present. What is much harder to estimate is the likely short-term timing and the more granular/ precise location of the extreme weather impacts relating to these larger-scale background climate signals that we as an industry are likely to see. Whilst technology and science have improved to allow us to arrive at these longer-term conclusions, our ability to make short-term climate predictions e.g. 10-20 years or weather extremes e.g. 6-12 months, is affected by the chaotic nature of the climate system and the natural variability that exists within our global climate system.

It is clear from previous comments that the climate is changing. However, the complicated relationship that exists between the components of the risk equation means it is not clear how risk will change in the future. The continued accumulation of exposure in areas impacted by climate related hazards means that risk continues to increase without any change in the hazard. But we know there are underlying changes in the climate which will affect how these localized extreme events occur in the future, though currently there is no clear science at the high resolution we need depicting the magnitude or direction of these changes. We also know that technology will advance and communities will adapt, so we need to factor these into the risk we face. What is clear is that this is a multi-dimensional problem that we as an industry are well placed to help inform.

Transition Risks

Transition risks related to climate change are the risks associated with a move towards a low- or net-zero carbon economy and typically arise from changes in three areas:

- Policy
- Technology
- Consumer preference and societal pressure

The severity of the financial risk and opportunity arising from policy, technology and preferential changes is markedly dependent on the speed at which these transitions take place. Regulators around the world are quickly realizing the potential impact that a transition to a low- or net-zero carbon economy might have and are working quickly to develop scenario tests of both an orderly and disorderly transition over various time periods. They are focusing on all industries that are likely to be affected to determine the resilience of their local financial systems.

The insurance sector will primarily feel the impact of transition risks through the impact on products sold driven by changes in demand, regulatory pressures, the activity of insureds and the nature of their assets.

Continued ➲

There are however other unique risks that the insurance industry must adapt to depending on the nature of the transition, which will impact the risk profile of our clients and our portfolios, such as:

- Increased rate of bankruptcy of companies in carbon-intense industries in a rapid or disorderly transition could lead to increased moral hazard.
- Reducing capital expenditure ("CAPEX") in carbon-intense assets due to gradual asset devaluation could arise in an orderly transition, with potential to impact both attrition and large loss experience. Severe CAPEX reductions could also be felt in a disorderly transition, resulting in the same risks but over a longer period.
- General financial uncertainty will likely give rise to an increasingly litigious environment.
- Positive press on the support of low-carbon industries and new products could drive an influx of capital in support of products with limited market size, meaning that support of these products could be unsustainable for carriers, a risk which will need to be considered by clients benefiting from short term low-prices.
- The wider social impact of our future actions needs to be considered if we choose to stop supporting carbon-intense assets with insurance, such as ensuring companies and sites are sufficiently funded to rehabilitate the environment.

Despite these increased risks, there is also a huge opportunity on the horizon. Estimates of the investment required to achieve the low-carbon transition range from USD 1.6 trillion to USD 3.8 trillion annually until 2050, for supply-side energy system investments alone (Inter Governmental Panel on Climate Change (IPCC) 2018), while the Global Commission on Adaptation (GCA 2019) estimates adaptation costs of USD 180 billion annually from 2020 to 2030[1]. The majority of Climate Financing is concentrated in mitigation activity, with low-carbon transport and renewable energy anticipated to attract the most investment whilst adaptation (water management, agriculture etc.) currently attracts much lower volumes of financing.

Whether or not the mix between mitigation and adaptation changes, the required investment in infrastructure and new technology is undeniable, which offers a huge opportunity for the Specialty Insurance market, particularly in areas such as energy, construction, transport, liability and trade credit.

Within AXA XL we have conducted detailed reviews and discussions with our underwriting teams across insurance and reinsurance to highlight the key transition risks for consideration:

- Asset devaluation and changes in energy sources could drive a change in risk profile and premium volume for the carbon-intense energy portfolio.
- Rapid changes in policy could lead to high rates of bankruptcy across a broad range of industries triggering trade credit claims and a rapid increase in frequency and severity of D&O and Professional Indemnity claims.
- Change in the valuation of assets with new technology introduces new risk profiles to traditional lines e.g. electric vehicles are worth a lot more than diesel vehicles and have longer repair times.
- Changes in regulatory and industry policy could impact property valuations as we look for assets to be more sustainable and resilient. A rapid transition could lead to undervaluation of physical damage and business interruption values as demand for new and less accessible materials increase.
- Consumer preference and/or an increase in carbon tax could reduce demand for certain products e.g. "flight shame" impacting the aviation industry and lead to a changing risk profile.

The time horizon and likelihood of these risks materializing is highly uncertain. Despite this, we need to contemplate their potential impacts through stress testing, continuing to improve our understanding of these risks whilst keeping our underwriters informed of changes both near-term and long-term to ensure that our underwriting reflects changes in risks arising from regulatory and industry policy, technology and consumer preference.

Liability and Litigation Risks

Liability risks associated with Climate Change are the risks that arise from actions initiated by claimants who have suffered loss or damage due to Climate Change. Today, there are over 1,700 live litigation cases related to Climate Change around the world, with over 1,300 filed in the US[2]. This number is ever increasing, and as a new and relatively untested area of law, progress to date has been quite slow. We can, however, learn from some recent rulings on the potential exposure that could be felt by the insurance industry.

Today, there are over
1,700
live litigation cases
related to Climate Change
around the world,
with over
1,300
filed in the US[2].

Continued ➲

Lawsuits for contribution to climate change have most commonly been launched on the basis of public/private nuisance or negligence but we are also increasingly seeing activity in product liability lawsuits.

Background on Climate Litigation

The majority of climate change related litigation has been brought by municipalities, states and even countries, with cases ranging from individual loss, corporate loss and class actions.

As with all litigation risks, the territory in which lawsuits are filed are a strong indication of exposure for insurance companies and the potential for an increase in related or "copy-cat" cases where there are strong litigious environments. Litigious environments currently highlighted in Climate Change litigation include the US, Germany and Australia. Whilst politics are left outside of the court room, actions taken by governments and pro-activeness in governments in fighting the physical impacts of climate change can all be drivers for increasing litigation. Therefore, the political landscape of litigious regions should be closely monitored in considering exposure to insurance companies.

Lawsuits for contribution to climate change have most commonly been launched on the basis of public/private nuisance or negligence but we are also increasingly seeing activity in product liability lawsuits. Such claims are often reliant on some of the longest chains of causation ever to be argued in courts, and yet the courts are increasingly willing to listen. Notably, claims are increasingly being sought to mitigate against future losses, as well as for current and direct impacts. Again, courts in some jurisdictions are showing willingness to listen to such arguments and where rulings come down against claimants, we are seeing cases being escalated through court of appeals, due to the unwillingness of those claimed against to settle and set a precedent of admission of liability.

The Future of Climate Change Litigation

In November 2019, Ralph Regenvanu, the foreign minister of the Pacific nation of Vanuatu, stated: "My government is now exploring all avenues to utilize the judicial system in various jurisdictions, including under international law, to shift the costs of climate protection back onto the fossil-fuel companies, the financial institutions and the governments that actively and knowingly created this existential threat to my country." Vanuatu is widely regarded as a nation that will feel the physical impact of climate change strongly and this stance from a political leader will likely be well received by the community and activists alike. Such urgent action and exploration of numerous avenues will undoubtedly lead to high legal costs for both the government and the defendants from whom they seek damages. Whilst this is not "new" litigation – an increasing number of US states taking similar action will only accelerate the time in which it takes for this new area of law to be determined, at the high cost of defendants and – potentially – their insurers.

The increasing sophistication of climate change litigation should also be noted. There has been a marked shift in the expertise and capability of climate change litigators, such as the emergence of Client Earth, a charity and campaign group consisting of well-respected lawyers with impressive capability and effectiveness. Client Earth's work in China is particularly notable, where they helped the government to write new environmental laws and trained lawyers and judges to support individuals and campaign groups to litigate to protect the environment. This is a demonstration of governments welcoming climate-related litigation and the use of the law to create positive environmental change.

As society continues to encourage climate change related financial disclosures, through the Network for Greening the Financial System and the Task Force for Climate-Related Disclosures (TCFD) recommendations, we are moving towards a much more transparent environment where climate change

Continued ➲

risk is concerned. Whilst these disclosures are a step in the right direction in addressing the impact of climate change on our financial system, disclosures and advertising campaigns can expose companies to litigation from inaccurate or inadequate disclosure claims and even advertising liability claims related to greenwashing if companies advertise that their green credentials are better than they are. The industry needs to be mindful of the changing risk profile that comes with increasing disclosure and the desire to be seen as "green" with increasing social movements in this space.

The actions of individual activists and campaign groups should not be underestimated in the evolution of climate litigation and liability. As social pressure mounts on governments and industries to take action on both the impacts of climate change and our impact on climate change, litigation is increasingly being used as a tool for change. The 2019 Urgenda decision and the November 2020 McVeigh v. Retail Employees Superannuation Trust (REST) settlement are examples of climate litigation concluding in significant actions being ordered and agreed respectively which then translate into transition risks. The Urgenda decision enforced a reduction in greenhouse gas emissions on the Dutch government of 25% compared to 1990 levels, to be achieved

The actions of individual activists and campaign groups should not be underestimated in the evolution of climate litigation and liability.

by 2020 and REST committed to being net-zero by 2050 and incorporating climate impacts into their investment strategy, not present prior to this settlement. All of these actions contribute to the local and global accelerations in the energy transition.

We cannot only consider the physical, transition and liability risks associated with climate change independently but instead must realise how they are entwined, and that the changing profile of each of these risks will both directly and indirectly affect the risk profile of the others. The use of litigation in enforcing action in the transition is an early demonstrator of this and considering how these risks are connected has supported AXA XL's development of climate change related stress tests.

1 Buchner, B. et al: Buchner, B. et al. Global Landscape of Climate Finance 2019 https://climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2019/
2 Litigation figures - http://climatecasechart.com/about/

About the Authors

Katie Lennon graduated with a Masters in Earth Sciences from Oxford University in 2012 before starting her insurance career in US Property Underwriting. During her time at AXA XL, Katie has held a variety of roles in Underwriting, Strategy and now Underwriting Management, with a focus on underwriting performance and governance. Katie is the Deputy Chair of the International Underwriting Association Climate Committee and leads the AXA XL UK Climate Change working group. Katie is based in the UK and can be reached at katie.lennon@axaxl.com.

Andrew MacFarlane has a BSc. Hons Actuarial Science & Statistics and FIA. He is Head of Pricing & Analytics for London & Bermuda for Reinsurance at AXA XL and a Partner on AXA XL's Leadership Council. In his Head of Pricing & Analytics role he manages the actuarial team across London and Bermuda supporting underwriters across a broad range of business lines and products. Andrew was involved in setting AXA XL's CSR strategy and is a member of the AXA XL CSR Steering Group. Andrew plays an instrumental role in looking to expand AXA XL's involvement in closing the protection gap and leads the Public Sector Partnership practice group at AXA XL. The aim of the group is to strengthen partnerships with the public sector in order to bring socially impactful insurance solutions to the market. Andy is based in Bermuda and can be contacted at: andrew.macfarlane@axaxl.com.

Natural Perils: Tropical Cyclones, Extra-tropical Cyclones and Wildfire

Natural perils are key contributors to the risks that we face as a (re)insurer. The hazards they present are prevalent all over the world, but their impacts are felt only in specific geographic regions, as it is the amalgamation of localised climatic and weather conditions, exposures and vulnerabilities that combine to create risk. AXA XL has carried out extensive research into the possible effects of climate change on the intensity and frequency of future climate peril systems, yet our ability to quantify the contributions from exposure and vulnerability remains a challenge. In the following sections we highlight some of the insights we have thus far gained into weather and climate hazards and point to areas of scientific and engineering research where AXA XL is progressing work on exposure and vulnerability.

Tropical Cyclones (TCs)

In terms of average annual losses, TCs are the costliest peril to the global (re)insurance industry. More widely, they are regularly devastating to human life, particularly in communities that struggle to incentivise disaster mitigation and resilience. Although TCs are given different names in different basins, they all form from the same physical processes and, once established, maintain a similar axisymmetric structure of rainbands which spiral inwards to an intense eyewall and an area of calm within the eye. Although formation is largely confined to the tropics, TCs regularly track into the mid-latitudes (i.e. poleward of 30°) and impact coastlines there as sub-tropical, post-tropical, transitioning or extra-tropical cyclones. The broad impact that TCs have had on society has led to significant research on the topic, and academic literature is rife with theorized impacts of climate change on global TC activity.

The following sub-sections outline a few of the aspects of TC hazard as it pertains to catastrophe modelling, and which of them AXA XL believes will play a crucial role in understanding TC risks under a changing climate.

Continued ➲

By John Wardman

Figure 1: Expected changes to frequency and intensity characteristics of tropical cyclones in the scenario where global temperatures increase by 2°C (the blue line shows the median increase and the bars the 5th and 95th percentile ranges) (from Knutson et al., 2020).

Average Frequency & Intensity

Knutson et al. (2020)[1] provided a comprehensive synthesis of modelling studies that look at basin-wide changes under a 2°C climate change warming scenario. A summary of their results can be seen in Figure 1, and the findings suggest that, on average, the frequency of TCs globally are projected to decrease by a median of 14%, while average intensities are projected to increase by a median of 5%. Knutson et al. also found the proportion of category 4 and 5 storms within the resultant frequency-intensity distribution increases by ~13% under this 2°C warming scenario, and that the rain rate of TCs is also likely to increase by ~14%. While such scenario tests offer valuable insight into the possible impacts of climate warming on global TC hazard, it is important to acknowledge the large uncertainty ranges around these projections, and note that for almost all regions, the uncertainty straddles the zero % change line, indicating low confidence in the exact magnitude of the changes, and also considerable uncertainty regarding the direction of the changes.

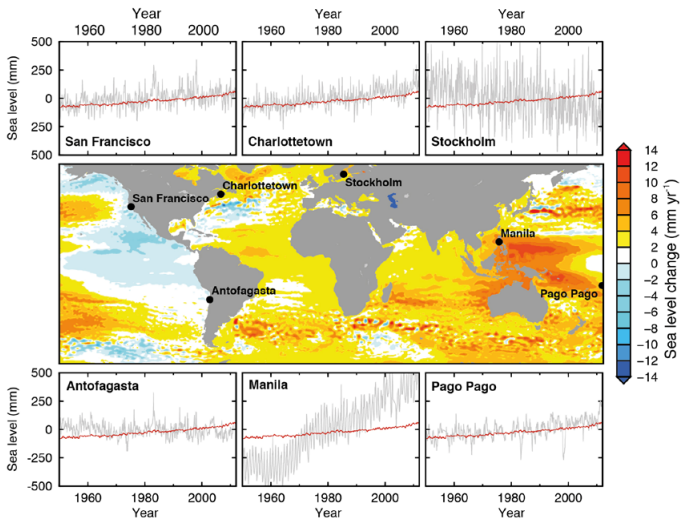


Figure 2: Global sea level changes relative to land since ~1950 with trends shown for certain places (grey lines = local change, red line = globally averaged trend)(from IPCC, 2013)

Sea Surface Height

It is well understood that sea level rise will, on average, increase the impact from TC storm surge. However, this picture becomes much more complex when we begin to disaggregate the global average to instead look at local impacts. At a local level, it is much more appropriate to use the term sea level change, because land is almost always in motion – either upward or downwards – but on extremely slow (i.e. geological) time scales; importantly, timescales between different parts of the land differ. Thus, in some areas land may be rising at a faster rate than sea level (e.g. from isostatic rebound, which is the gradual rise of land masses in response to the receding of heavy ice sheets emplaced during the last glacial period), and thus risk from storm surges would actually be decreasing. Figure 2 (from the IPCC AR5, 2013)[2] shows how sea level relative to land is changing around the world, along with trends in select locations (grey lines = local change, red line = globally averaged trend). For instance, while Manilla is quickly becoming more susceptible to storm surge impacts, places like Stockholm seem to be on a slightly decreasing trend.

Continued ➲

...in the short-term (i.e. next 10 years), AXA XL believes the biggest driver of change in TC risk will be from continued accumulation of wealth and assets in areas with pre-existent material hazard.

Translation/ Forward Speed

Translation speed (defined as the speed at which a TC shifts from one point in space to another) is an important feature because the slower TCs move, the longer their influence time, and the greater the potential societal impact of associated hazards such as heavy rain and strong winds. However, there is much debate around the changes that have been observed in translation speeds for global TCs. Recent research has shown that there was a 10% slowdown in global tropical-cyclone translation speed over the 68 years between 1949 and 2016 (Kossin, 2018)[3], in part due to the weakening of tropical circulation brought about by anthropogenic-induced climate change. However, this claim is refuted when analysing data from the period of satellite observation (i.e. from the 1970s), which is considered more accurate and reliable (Lanzante, 2019)[4]. The relationship between the slowdown of TCs and anthropogenic warming, is therefore, not clear, and the relevant potential increase in local rainfall totals under a future warming climate is also not clear. This contradiction highlights the uncertainty that exists within the science and the need to remain objective when developing our view of TC risk.

The abovementioned aspects of TC hazard are not novel concepts and represent the findings from decades of in-depth and intense analysis by industry and academic experts alike. Generally speaking, the (re)insurance industry has a much weaker understanding of TC vulnerability and exposure, and ongoing analysis at AXA XL suggests that, in the short-term (i.e. next 10 years), we believe the biggest driver of change in TC risk will be from continued accumulation of wealth and assets in areas with pre-existent material hazard. We are focused on strengthening our understanding of exposures by enhancing our data, whilst exploring how future exposures and vulnerabilities might evolve in response to the changes in the hazard we expect to see.

Extra-Tropical Cyclones (ETCs)

ETCs are the scientific terms for EU windstorm, US winter storms and other synoptic scale-scale (~100km) storms that occur at the mid-latitudes. Although similar to TCs in that they (i) see large scale cyclonic flow that spirals in towards a centre and (ii) are associated with extreme winds, precipitation and, in some regions, storm surges, there are fundamental differences in their formation mechanisms and structure that make them very distinct from TCs. While TCs form from atmospheric instability that is usually the result of a pre-existing convective disturbance at the surface and mid-levels of the troposphere, ETCs form from a type of upper-level instability called baroclinic instability. This is where disturbances in the atmosphere are created that ETCs can feed off. Typically, you can think of them as areas where you see clashes of poleward and equatorial air masses. Although theoretically they can form at any time of the year, they tend to form most often during winter seasons as the gradients between poleward and equatorward air masses tend be at their strongest. There is less literature when it comes to impacts of a changing climate on ETCs, but work that has been done to date has focused on the frequency and intensity changes across the mid-latitudes. Work done by Catto et al. (2011)[5] looked at three different climate scenarios to investigate the impacts that these might have on future ETC activity. Their findings were inconclusive as irregular changes were apparent across the entirety of the northern hemisphere and there did not appear to be an overall clear average increase or decrease of storm activity under either scenario (rather, it was the patterns which seemed to shift). In a later study, Catto et al. (2019)[6] attempted to synthesize some additional research on ETCs and concluded that results from future modelling of the peril remain inconsistent and therefore difficult to infer reliable information from the studies. They hint, however, that the models point to a change, but that predicting precisely how that will happen is beyond contemporary science at the moment.

As with TCs, vulnerability and exposure are the components of the ETC risk equation which have received the least amount of research focus to date. Rather than hinder our work on quantifying climate change impacts, near-term focus on exposure and vulnerability will more readily help us to constrain the hazard impacts that we may see in a changing climate. AXA XL has initiated this research roadmap and is engaging with leading experts to fill crucial knowledge gaps.

Continued ➲

Wildfire

Wildfire, like most climatically linked hazards, is highly episodic in many parts of the world. However, unprecedented insured losses from catastrophic wildfires in California during 2017/18/20 and the substantial area of burned land during the 2019-20 Australia bushfires raise the question of whether we are entering a new phase of heightened wildfire activity. As the sophistication of contemporary wildfire risk models lags behind that for more frequent and material perils such as North Atlantic windstorm, it is essential that we propel independent research and forge partnerships with leading experts on the topic. Recent incentives at AXA XL seek to do just this: to better understand the key drivers of wildfire hazard, vulnerability and exposure.

On Hazard

Sparse global fire-climate projections suggest there will be spatially variable responses in fire activity, including strong increases and decreases (Figure 3) due to regional variations in the climate–fire relationship, and anthropogenic interference (Moritz et al., 2012)[7].

These findings propose that populated areas of the US, Europe, Australia, and the western side of the Andes in South America will see substantial increases in fire danger and fire activity (i.e. hazard). However, the diversity of modelling approaches and failure to incorporate the influence of vulnerability and exposure on the risk equation confounds efforts to synthesise how changes might occur globally. Thus, we must always look locally when estimating likely changes to wildfire hazard. As a recent collaboration between AXA XL and wildfire experts from the University of California at Merced highlights, future wildfire regimes will be affected differently in different biomes, and changes in hazard from climate change is but one of several equally important factors driving future wildfire risk.

On Exposure

Rapid growth in the wildland-urban interface (WUI) has increased the risk to vulnerable populations. The largest insured losses consistently occur in the WUI, and a study by Kramer et al. (2018)[8] found 82% of all US buildings destroyed by wildfire between 1985–2013 were in this zone. Population and associated infrastructure growth introduce more sources of ignition and lead to suppressed fires, allowing the build-up of excess fuels. The result has been a change in the frequency of large fires (the hazard), demonstrating that the impacts from increasing exposure on overall wildfire risk are far reaching.

Recent work by Alexandra Syphard (2020)[9] looked at the change in urban development and wildfires over 60 years in San Diego County, California (Figure 9). Whereas no homes were destroyed during the 1940s, more than 5,000 were destroyed in this same area during the 2000s despite similar levels of fire frequency. An 871% increase in development between these time periods is further evidence that human expansion into an already flammable landscape is a primary driver of losses. Future research in this space at AXA XL will therefore look to quantify the impact that population growth has had on overall wildfire risk, and to develop strategies to further manage exposure in an evolving risk landscape.

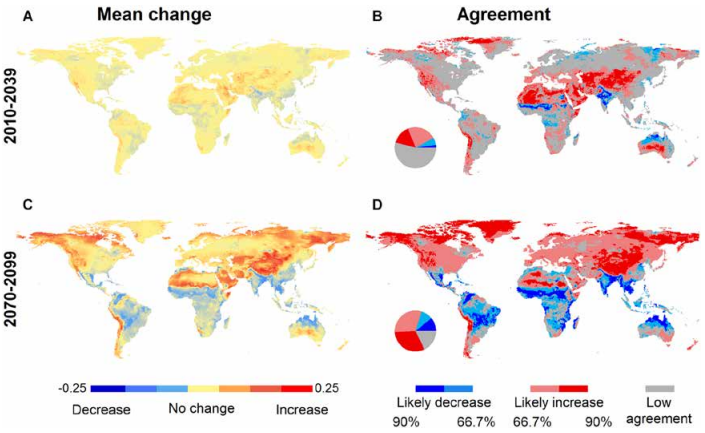


Figure 3: Ensemble mean change (A, C) and degree of model agreement (B,D) in predicted fire probability for 2010-2039 and 2070-2099. Pie charts indicate global proportions in each agreement class: likely decrease, likely increase and low agreement correspond to 8.1% and 54.1% for the 2010-2039 period, and to 20.2%, 61.9% and 17.9% for the 2070-2099 period (from Moritz et al., 2012)[7].

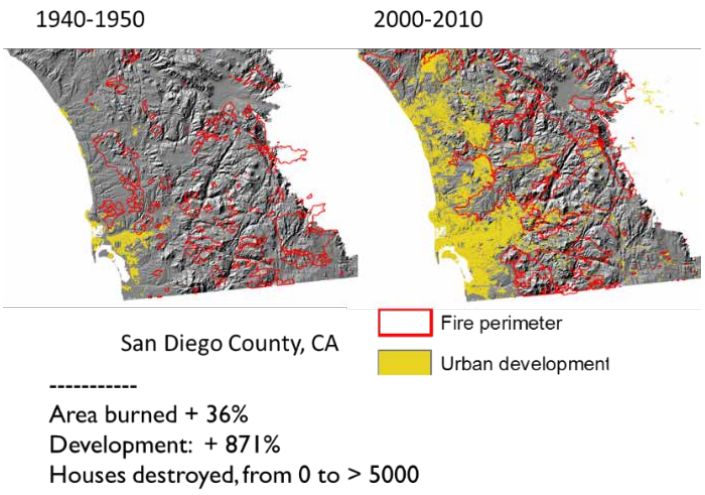


Figure 4: Changes in fire activity and urban development over a sixty-year period in San Diego County, California. While no homes were destroyed in the 1940s, more than 5000 were destroyed in the 2000s, as development grew by 871% Syphard (2020)[9]. This contrasts with the moderate change in area burned (+36%) over this same period.

Continued ➲

On Vulnerability

From 2005 to 2020, wildfires have destroyed more than 89,000 structures across the United States (Barrett, 2020)[10]. Many of the conditions which facilitate large and high-intensity wildfires are not necessarily conducive to structure (i.e. insured) loss. The vast majority of wildfire prediction modelling to-date has focused on predicting ignition, fire spread, and basic fire behaviour across vegetation, with very little to no prior research on how vegetation fire quantitatively transitions from the landscape to structures and subsequently destroys them. AXA XL regularly communicates with third-party vulnerability experts such as the Insurance Institute for Business and Home Safety (IBHS) to obtain insight into the best practices for reducing wildfire risk to homes in suburban areas and/or the WUI.

Considering the binary nature of observed structure damage from fire (i.e. wildfire damage to structures tends to be either minimal or a complete loss), AXA XL is working to identify the key drivers of structure vulnerability to support clients in mitigating their wildfire risk, either through hardening of structures using fire-resistant material and/or reducing the intensity of a potential fire around the structure. Improving data capture and the quality thereof from our clients will further augment our efforts to develop robust wildfire risk prevention strategies.

Conclusions

TCs: TC impacts are a primary driver of annual losses within the (re)insurance industry. AXA XL stays abreast of the science to ensure that we are objectively factoring in the latest views into our views of risk. Although there is some evidence to suggest that some aspects of TC hazard may increase in the future (e.g. precipitation, wind), other aspects of it may decrease (e.g. frequency). The slow speed with which these signals will become clearer means that our focus in the short-term should be around the exposure and vulnerability when thinking about the risk we face as (re) insurers.

ETCs: Historical statistics of ETCs show that there have been no reliable/ detectable climate change trends at all in frequency and intensity of ETCs in the recent past. However, the scientific community is largely in agreement that climate change will cause a change to frequency and intensity patterns of ETCs going forward, but it is far beyond reliable science to say exactly how and at what timescales. Given this uncertainty in ETC hazard, we aim to continue our focus on aspects of exposure and vulnerability to ensure we understand holistically the risks we face from ETCs.

Wildfire: AXA XL actively engages with leading experts in the field of wildfire science and engineering to develop robust views of risk. Ongoing work focuses on understanding the relative contribution to risk from the three components of hazard, vulnerability and exposure. Working closely with leading experts from each of these fields, we intend to expand our understanding of this hazard in order to provide greater insights for ourselves and our clients.

References

1 Knutson, T., Camargo S. J., Chan J. C. L., Amanuel K., Ho C-H., Kossin J., Mohapatra M., Satoh M., Sugi M., Walsh K. and Wu L (2020). Tropical Cyclones and Climate Change Assessment - Part II: Projected Response to Anthropogenic Warming. https://doi.org/10.1175/BAMS-D-18-0194.1

2 IPCC, (2013): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.

3 Kossin, J. P. (2018). A global slowdown of tropical-cyclone translation speed. Nature, 558(7708), 104-107.

4 Lanzante, J. R. (2019). Uncertainties in tropical-cyclone translation speed. Nature, 570(7759), E6-E15.

5 Catto, J. L., L. C. Shaffrey, and K. I. Hodges, 2011: Northern Hemisphere Extratropical cyclones in a warming climate in the HiGEM high-resolution climate Model. J. Clim., 24, 5336–5352.

6 Catto, J. L., Duncan Ackerley, James F. Booth, Adrian J. Champion, Brian A. Colle, Stephan Pfahl, Joaquim G. Pinto, Julian F. Quinting & Christian Seiler (2019): The Future of Midlatitude Cyclones. Current Climate Change Reports, 5, 407–420.

7 Moritz, M. A., Parisien, M. A., Batllori, E., Krawchuk, M. A., Van Dorn, J., Ganz, D. J., & Hayhoe, K. (2012). Climate change and disruptions to global fire activity. Ecosphere, 3(6), 1-22.

8 Kramer, H. A., Mockrin, M. H., Alexandre, P. M., & Radeloff, V. C. (2019). High wildfire damage in interface communities in California. International journal of wildland fire, 28(9), 641-650.

9 Syphard, A. D. (2020). Trends and drivers of wildfire activity and structure loss in California. Proceedings of the Cat Risk Management Conference, Orlando, FL, February 2020.

10 Barrett, K. (2020). Wildfires destroy thousands of structures each year. Headwaters Economics. Accessed 20 November 2020.

About the Author

John Wardman, PhD, FGS, is a Senior Specialist on the AXA XL Science & Natural Perils Team where he helps to build and inform views of catastrophe risk, assist CAT model evaluation and validation, and support product development. John's role also includes engaging with scientists and university departments from around the world, facilitating the translation of academic research into business impacting information and data. John is based in the UK and can be reached at john.wardman@axaxl.com

The Importance of Exposure Modelling

The Importance of Exposure

Risk is a function of hazard, exposure and vulnerability and understanding exposure is a key aspect of the risk equation and critical in understanding the risk we face both now and in a changing climate. Exposure is defined as the amount of an asset that is exposed to the hazard in a given space and time. Without any exposure, we do not have any risk.

For example, in 2013 the category 5 typhoon Lekima in the North West Pacific Ocean had peak wind speeds of over 240km/h, however it caused no casualties or damage to property due to its location. In the same year Typhoon Haiyan, a category 5 storm hit the region of Yolanda, with peak windspeeds of over 315km/h. Haiyan affected nearly 11 million people, causing more than 6,000 casualties and the loss of more than USD$1.5 billion. It is clear from these examples the importance that exposure plays in determining the risk that is faced from a particular event.

In this section we describe what is being done by AXA XL in understanding clients' exposure from a data quality, data enrichment, risk insight and event response perspective.

Data Quality: Evolving Over Time?

When it comes to data collection and data analysis, the insurance industry has come a long way over the last 20 years. In the late 1990s data was provided in spreadsheets with aggregate exposure data in the US, whereas in the early 2000s data was primarily provided in vendor model databases with some improvements in data quality. We are now seeing data provided at street level and in some instances at building level. Having this detail is important for a hazard like wildfire or flood, where the damage can be isolated at building level. These improvements are also beginning to be seen in other territories like Europe but data quality still remains poor in a number of other larger territories and non-peak less well modeled zones.

Continued ➲

By Mojum Khan

At AXA XL we provide our underwriters with data quality reports for each of our clients, highlighting where we see issues and building up a risk ranking framework allowing us to gain insight on relative performance of our clients. In certain territories we are driving conversations with both our brokers and clients to improve the data quality and providing insight into what is driving loss uncertainty.

Data Enrichment: Ground Truth Florida Property Risks

Whilst we have highlighted improvements in the granularity of data being provided, there is a new issue that needs to be addressed which is how this data compares to the ground truth of the actual property. For example, how does the roof geometry or roof type provided by clients match with what we see from spatial imagery of the property? (Figure 1)

For this purpose, we have partnered with a third-party company called Cape Analytics. Using their programming interface, we have enriched roof geometry and roof type secondary modifiers for our Florida clients as these both have a significant impact to the vulnerability of a structure in a tropical cyclone event. The enriched client locations yield a 0-20% difference in expected loss compared to the original loss. We are now looking to expand our discussions with Cape Analytics to detect roof condition (proxy for age), tree overhang, proximity to trees and the presence of debris. We feel that the addition of these attributes to the roof geometry will get us closer to the true view of exposure and so a clearer understanding of risk, especially in wind and wildfire exposed states. Data enhancements are key to us improving our ground truth and alongside the above description, we also make use of data from other sources, like taxation data from the US, to assess these ground truths and continue to enhance the detailed data that we have available to run in our vendor models.

Figure 1: Aerial imagery clip used by Cape Analytics for their deep learning analysis in extracting building attributes and hazard proximity

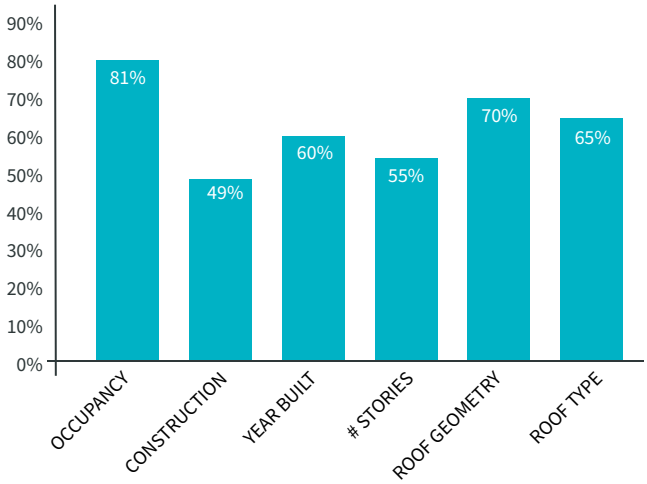


Figure 2: Comparing building attribute data provided by our cedants to ground truth (Taxation and Imagery Based)

Continued ➲

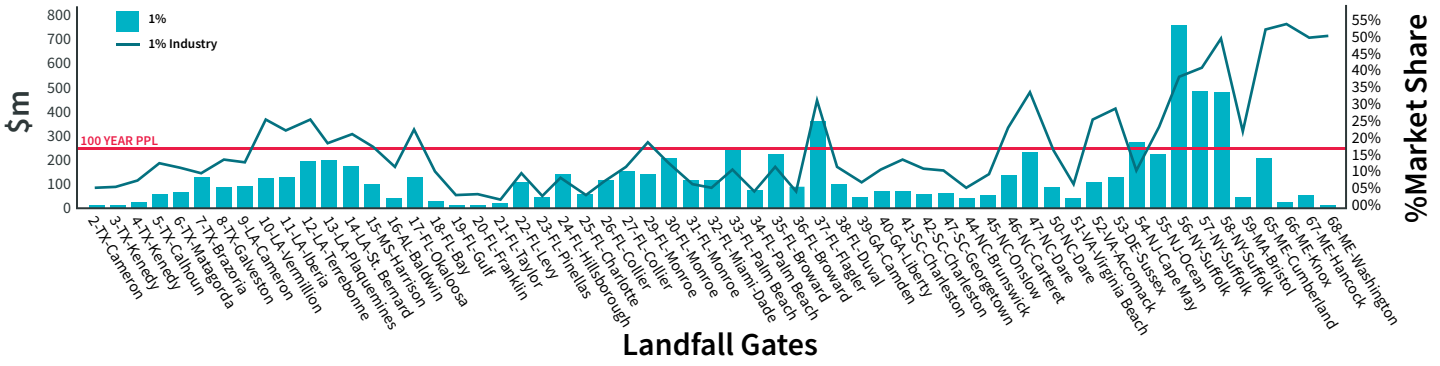


Figure 3: Given a hurricane has occurred, what is the 1% chance of loss for different landfall gates, compared to 1/100 PML and Industry

Risk Insight: Understanding Risk Profiles

One way to ensure we understand the risk profile of our clients, removing the ever-changing annual frequencies in landfall events from our models, is to take a deterministic perspective on our risk. For example, why not simply ask the question "If a category 3-5 event made landfall what could our potential loss be?" Figure 3 demonstrates how we would look to answer this question.

The above graph removes uncertainty around frequencies and shows the results for losses for various categories of storms and whether they exceed a 1% chance of exceeding a certain level. This level of insight allows clients to ascertain areas of peak exposure and consider the applicability of that exposure within their overall portfolio.

Continued ➲

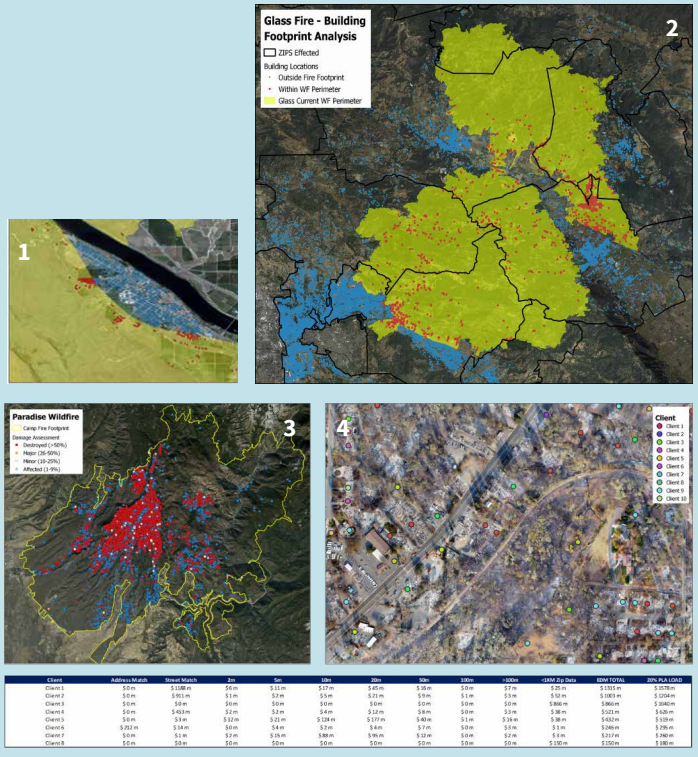
Event Response Case Study: US Wildfire Estimation

The importance of good data is becoming even more apparent with the many US wildfires generating significant losses in recent years. These events can have a footprint which is smaller than a zip code yet can drive billions of dollars in losses. Furthermore, we often see properties completely destroyed adjacent to others which are untouched.

At AXA XL our initial process involves utilising the fire footprints provided by the fire brigade and assessing our clients' exposure. Where clients provide granular resolution data, we try to correlate these risks to properties that have been damaged or destroyed. Pulling all this information together gives us a more complete picture of the event that we are exposed to whilst also allowing us to benchmark modelling agencies' assessment of market losses and have meaningful conversations with our clients about their potential losses.

It is clear from the analysis (below, right) the numerous ways that exposure is a key driver of the risk we face. The improvement in the data that we use to model the risk along with the gains we have seen in recent years means that we are able to have a much clearer understanding of the characteristics of all the assets that we insure. We will continue to improve our data and aim to assess how exposure will change over time. This will include not only improving aspects around data quality but also how populations might change, what impact urbanization will have on exposures along with how assets are distributed to get a fuller picture in terms of how changes in exposure might impact the risk we face from a changing climate.

1. **Property within the fire perimeter adjacent to others which are untouched.**
2. **Size of fire perimeters relative to US Zip Codes**
3. **Data provided by California fire brigade with respect to properties damaged/destroyed**
4. **Correlating client exposure to properties damaged/destroyed**
5. **Using proximity to damaged/destroyed properties to ascertain client loss estimates**



About the Author

Mojum Khan has a BSc in Mathematics and Statistics and has been working in the Insurance industry for more than 15 years, starting as a Risk Analyst at Aspen Insurance. He joined Catlin in 2007, later XL Catlin and now AXA XL, working in the Reinsurance Cat Modelling function. The key focus of his role has been on Event Response, Exposure Analytics, London Re Cat Modelling Portfolios and Pricing Management and bespoke AXA XL tool developments. Mojum is based in the UK and can be reached at: mojum.khan@axaxl.com.

Market Resilience

Articles about how our company and industry, through innovation and collaboration, are exploring new approaches to risk modelling and developing customized solutions to address the impact of climate change

Product Innovation:
Index Insurance

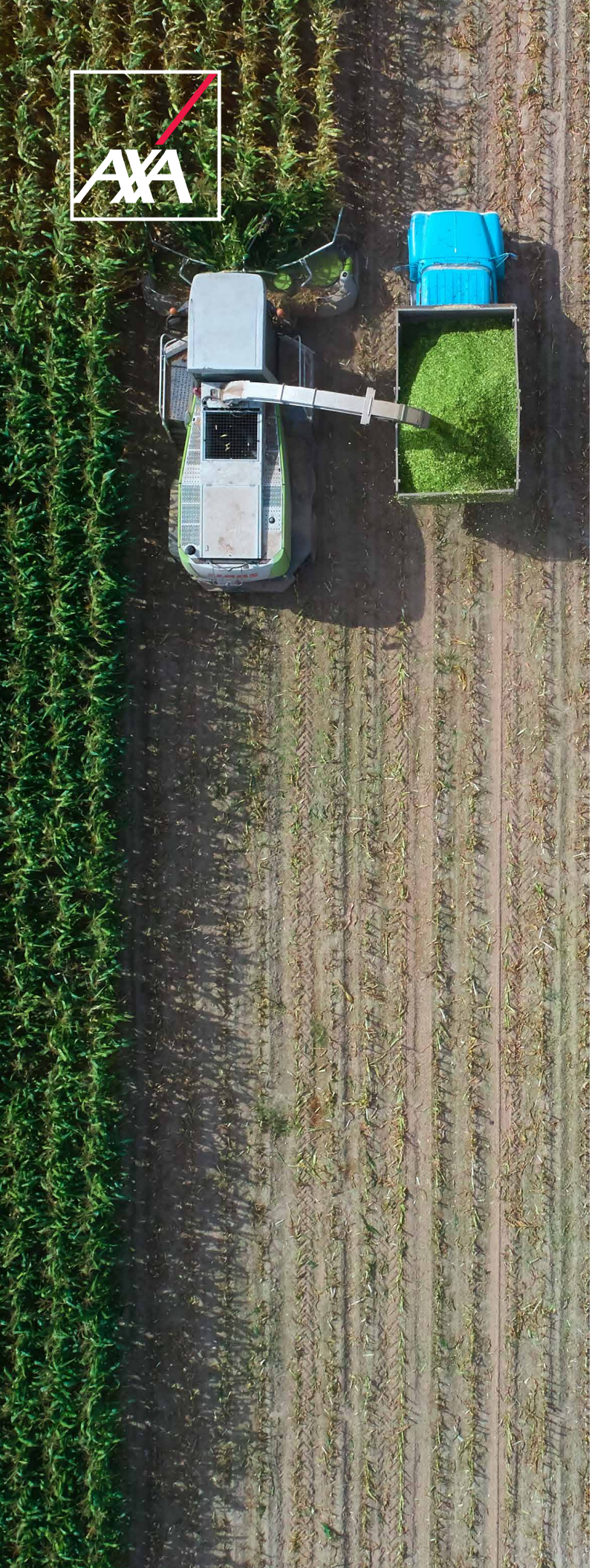
Diversification of
Atmospheric Perils

Performance Insurance Solutions
for Breakthrough Technologies

North Atlantic Hurricane Risk:
Counterfactuals

Ocean Risk and Resilience

Predicting Structure Loss from Wildfire



Product Innovation: Index Insurance

In the agricultural risk transfer world, the concept of index insurance is well-established, and has been around for several decades. It aims to simplify the insurer to customer chain by triggering a payout based on an objective proxy for loss. Although simplifying the more traditional insurance chain by removing the cost of potentially complex claims processes, the proxy and trigger system introduces “basis risk” into the insurance product.

Basis risk can be described simply as a mismatch between the amount of payout and the value of the actual loss suffered by an insured. Basis risk is a key reason for the limitation of index insurance to:

- certain classes of business in which the proxy shows a good relationship with loss, or
- locations in which the cost of the traditional claims process makes traditional insurance products prohibitively expensive.

During recent decades, the data associated with a wide range of different remote sensing (i.e. satellite data and associated rainfall, vegetation) and agroclimatic variables (potential evapotranspiration, water-balance, soil moisture) have been made freely available to the public. This increased data availability can help to offer farmers better protection against extreme weather. To achieve this, data underlying parametric insurance schemes should be carefully selected and/or combined taking local contexts and data uncertainty into account. Eventually, the resulting index should be well-validated[1].

Continued ➲

By Niklaus Lehmann, Beat Krauer and Willemijn Vroege

Novel Parametric Insurance Scheme at the Meso-Level in Nicaragua

AXA XL's Global Agriculture team along with Incofin Investment Management[2] and two local Nicaraguan insurance companies have developed a novel parametric insurance program for smallholder farmers in Nicaragua. Launched in 2017, in collaboration with three Nicaraguan microfinance institutions (MFIs), this program helps protect 10,000 coffee and grain farmers, more than 90 percent of whom possess fewer than 10 hectares of land. The scheme covers both excessive rainfall and prolonged drought.

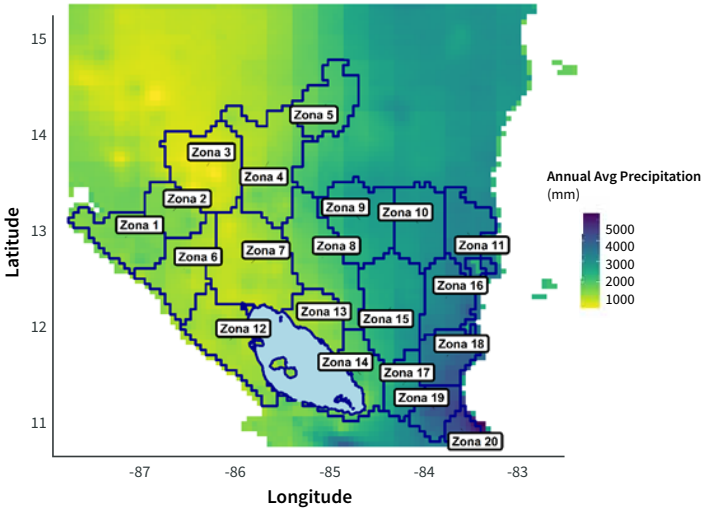
In places like Nicaragua that contain many different microclimates and where farmers grow a variety of crops, basis risk is magnified. For example, coffee is grown in mountainous districts that are cool and wet, while grain farms occupy the warmer, drier coastal areas. A single index for the entire country, or even four or five indices covering different regions and crops, would have led to considerable basis risk.

Here basis risk was minimized by splitting the country into twenty units based on their similar climate conditions (see Figure 1). In addition, specific indices were developed for all crop types included in the MFIs' insurance portfolios. Although that meant creating separate models for each zone and crop, the index values derived from these individual models are highly correlated with outcomes in these smaller, more homogeneous areas thereby reducing potential basis risk.

Another critical consideration when designing parametric programs for each zone was where to set the thresholds when payouts are triggered. Lower threshold levels provide protection for more frequent events and typically are more expensive. Conversely, higher thresholds protect against less common threats and often are relatively less costly. After extensive discussions with the MFIs and a survey of three thousand smallholder farmers, we set the threshold levels for both excess of rain and drought events to cover not only catastrophes but also what we characterize as medium-magnitude events. For excessive precipitation, payouts are triggered even when the rainfall totals are only about 50% above average; for drought, payments are made when the lack of rain is only slightly below average values. Basing the thresholds on more frequent but still destructive medium-magnitude events has proven to be quite effective in fostering greater resilience and stability in rural parts of Nicaragua. Historical analysis indicates that the resilience of a community won't necessarily deteriorate markedly after medium-magnitude weather events. That's evidently because many farmers avoid defaulting on their loans by selling capital assets or taking out second loans. The downside is that the impact of the next damaging event is amplified because farmers are in more precarious states due to ramifications from the previous event.

> The increased availability of remote sensing and ancillary data sets can help to offer farmers better protection against extreme weather.

Figure 1: Homogenous climate zones in Nicaragua



One of the as-yet-unanswered questions about programs like this is what effect they could have in boosting confidence among MFIs to invest in the challenging agricultural sector. A related issue is whether the increased protection that parametric-based coverages deliver will help attract additional private investment in areas that are now more economically stable and secure.

A further example of potential for index-based insurance relates to work we have been doing looking at grasslands insurance (Vroege et al., 2019)[3]. Grasslands make up the biggest part of the world's agricultural area. Even though a farm's grassland production can vary substantially from one year to another, the global penetration of insurance for grassland systems is low.

Continued ➲

AXA XL Reinsurance's Global Agriculture team has evaluated the effectiveness of a wide range of different weather and remote sensing variables as proxy for grassland productivity. Table 1 shows the correlation between grassland productivity and a selection of agroclimatic and vegetation indices at the municipality level for Switzerland. First of all, it should be pointed out that for all indices, correlation coefficients are only moderately strong mainly because only qualitative estimations were available for the grassland productivity[4]. Notwithstanding these limitations, our analysis clearly shows that the water balance[5] and the fCover significantly outperform precipitation as a proxy variable for grassland productivity. In particular, fCover, which corresponds to the fraction of ground covered by green vegetation measured by satellites from space, has a high potential as an index variable for grassland productivity. This finding is very much aligned with scientific literature demonstrating the high suitability of fCover as an index proxy for parametric grassland insurances (Roumiguié et al., 2015)[6].

Table 1: Correlation between selected Indices and Grassland Productivity in Switzerland

Index Variable	Correlation
Precipitation	0.42
Potential Evapotranspiration	-0.46
Water Balance	0.44
fPAR	0.33
fCover	0.52
Dry Matter	-0.18
NDVI	0.38

In order to cross check our findings in other geographies, we conducted the same kind of analysis in France and Manitoba (Canada). While the lack of granular grassland productivity data didn't allow us to perform the evaluation at the same depth, the general results obtained for France and Manitoba are very much in line with our findings in Switzerland. Even though, climatic growing conditions vary substantially across the countries, in all geographies fCover proved to be a very suitable proxy in measuring the productivity of grasslands.

These two examples indicate the progress that we continue to make regarding the use of parametric insurance as an additional tool to address some of the growing risks we face as an industry. Shifting our analysis away from focusing purely on the hazard towards understanding what drives the loss allows us to create more meaningful indices, reducing basis risk and creating more affordable and sustainable insurance products.

References:

1 Vroege, W., Vrieling, A. and Finger, R., Satellite support to insure farmers against extreme droughts, Nature Food, March 2021, DOI :10.1038/s43016-021-00244-6
2 Incofin Investment Management is an impact investor with a history of investing in financial institutions and the agricultural sector in emerging markets.
3 Vroege, T. Dalhaus, R. Finger, Index insurances for grasslands – A review for Europe and North America, *Agricultural Systems*, Volume 168, January 2019, pp. 101-111
4 Qualitative grassland productivity data was converted using a standardization approach into quantitative variables.
5 The Water Balance is defined as the daily difference between precipitation and the potential evapotranspiration.
6 A. Roumiguié, A. Jacquin, G. Sigel, H. Poilvé, B. Lepoivre, O. Hagolle, Development of an index-based insurance product: validation of a forage production index derived from medium spatial resolution fCover time series, *GIScience Remote Sens.*, 52 (2015), pp. 94-113W.

About the Authors

Niklaus Lehmann is a Senior Agriculture Underwriter with AXA XL's International Reinsurance business. Niklaus holds a Ph.D. in crop modelling from ETH Zurich and is always open to discussing new insurance solutions for protecting agricultural production. Niklaus is based in Switzerland and can be reached at: niklaus.lehmann@axaxl.com.

Beat Krauer heads the Agriculture Reinsurance Team at AXA XL's International Reinsurance business. With a background in forestry engineering and statistics he is as passionate about the farming business as our clients and their customers. He sees genuine long-term partnership and an innovative mindset as crucial to help clients to bring their business further. Beat is based in Switzerland and can be reached at: beat.krauer@axaxl.com.

Willemijn Vroege is an Agriculture Underwriter with AXA XL's International Reinsurance business. Willemijn holds a Ph.D. in Agricultural Economics from ETH Zurich and has a strong interest in using (new) technologies to insure agricultural production, specifically in the context of climate change. Willemijn is based in Switzerland and can be reached at willemijn.vroege@axaxl.com.

Performance Insurance Solutions for Breakthrough Technologies

Mitigating and reversing climate change is arguably the greatest opportunity for innovation ever seen by humanity. Technology developers and their partners are stepping up to this enormous challenge with creative solutions that are both impactful and commercially viable. While new technology comes with risks, risk cannot stop us from creating a better future.

New Energy Risk ("NER"), a California-based majority-owned indirect subsidiary of AXA XL, a division of AXA SA, works with diverse and global clients to support technology breakthroughs solving global challenges, including in energy, pollution, and decarbonization. Its team of scientists and insurance professionals utilize NER's proprietary, technoeconomic modelling to evaluate novel risks. The company partners with start-ups, developers, lenders, investors, re/insurers, and brokers to structure customised performance insurance solutions.

NER's performance insurance solutions seek to mitigate technology risk for clients—and their customers and lenders as a result—by transferring specific and carefully calibrated technology and financial risks to the insurance markets. As a result, NER brings a new class of diversified risk to the insurance market that addresses major environmental issues. To date, NER clients are supported by $USD1 billion in total insurance capacity.
With its proven platform, NER adapts to emerging sectors by designing bespoke insurance solutions for commissioning, operating output, revenue swaps, business interruption, and warranty or feedstock backstops. Industries of focus include fuel cells, energy storage, energy efficiency, waste-to-value (e.g. biogas and biofuel production), and carbon capture.

Continued ➲

By Tom Dickson, CEO of New Energy Risk

NER clients include:
- Fulcrum BioEnergy, a trash-to-biofuel developer;
- Bloom Energy, the leading supplier of solid-oxide fuel cells; and
- Brightmark, a plastic waste-to-product technology company.

With well-structured packages, NER clients gain access to otherwise inaccessible financing. By enabling capital efficiency, new technologies advance more quickly from development to deployment and commercial scale with widespread customer adoption. In five years, NER clients have unlocked over $USD 2 billion in capital for their technologies.

NER client impact includes:
- **Waste processing: 449K tons/year** (The amount of trash produced each year by 545,565 US residents.)
  Reducing landfills and building a circular economy, NER clients convert trash into valuable products like transportation fuels and specialty waxes.

- **Clean energy generation: 695K MWh/year** (The amount of power used per year by 63,343 US homes.)
  Reducing dependence on aging centralized power grids, NER clients provide reliable, cleaner power.

- **Alternative fuel production: 50M Gal/Year** (The amount of fuel used per year by 88,809 US drivers.)
  Reducing transportation's dependence on petroleum, NER clients produce better fuels by circulating waste back into the value chain as a solution for overflowing landfills.

- **CO2e Avoidance: 320K tons/year** (The amount from flying roundtrip, New York City to San Francisco, by 491,665 passengers.)
  By preventing harmful greenhouse gas emissions, NER clients are displacing carbon dioxide and its equivalents to slow down our worsening climate crisis.

By enabling capital efficiency, new technologies advance more quickly from development to deployment and commercial scale with widespread customer adoption.

NER-developed policies are underwritten and issued by one of the affiliated insurance companies of AXA XL and administered by its subsidiary Complex Risk and Insurance Associates, LLC, licensed in California (#0I24307). Learn more about New Energy Risk at www.NewEnergyRisk.com

About the Author

Tom Dickson, CEO of New Energy Risk since 2015, has more than 35 years of experience in the insurance and reinsurance industry; including senior executive and underwriting leadership positions in the US, Europe, and Asia; notably as the former CEO and Chief Underwriting Officer of the Centre Group, a $10B reinsurer that pioneered innovative products to address high-value business risks and financing. Tom has also served on the boards of public and private companies, including Flagstone Re, Paragon Insurance Services, Reformation Insurance Services, and as an advisor to Cellcontrol. Tom graduated with honors from Stanford University and holds a Master's degree from John Hopkins University (SAIS).

Ocean Risk and Resilience

The ocean is fundamentally linked to the climate system, acting as a regulator and buffering the damaging effects of climate change. However, as a consequence, the ocean is changing faster than at any time in human history, posing threats to the lives and livelihoods of billions of people, most of them in the poorest and most vulnerable communities.

AXA XL's Ocean Risk Initiative was launched to utilise its risk management expertise and AXA Group's investment appetite to define and understand ocean risk. The initiative also aims to develop pioneering finance and insurance products that build resilience and reduce the impact of ocean risk on exposed communities.

Driving Product Innovation

Coastal flooding impacts are increasing due to coastal development, population growth, climate change, and habitat loss. Maintaining and regenerating existing coastal ecosystems that help protect people and property is a critical component of disaster risk management and climate adaptation in countries that often lack the financial resources to fund relief and post-disaster recovery efforts.

Over the next 25 years, the global benefits of mangroves in averting flooding and damages for property is calculated to be $USD 104 billion[1]. For 100-year storm events, flood damages would increase by 91% to $USD 272 billion without coral reefs[2].

These examples, alongside other marine ecosystems provide natural protection against the impacts of storms, but also provide significant socio-economic and ecological benefits including supporting local jobs, maintaining food security, sequestering carbon and promoting biodiversity.

Continued ➲

By Chip Cunliffe

Coastal Risk Index

Despite their role in protecting lives and property, the value of coastal ecosystems is often disregarded and not accounted for in either industry risk models or development priorities.

AXA XL is working with its scientific partners to develop a ground-breaking Coastal Risk Index (CRI) that integrates the protective benefits of coastal ecosystems into insurance risk models. The Index will calculate physical risk to coastal assets in different projected flooding scenarios up to 2050, with and without coastal ecosystems. It will then measure two further parameters: social vulnerability and the fiscal risk caused by the loss or degradation of those ecosystems.

The Index will enable insurers to price and transfer risk more accurately, allowing policymakers and investors to direct financial flows more effectively and catalyse behavioural change towards proactive coastal ecosystem management.

The CRI aims to drive a systemic shift in how the insurance industry measures coastal risk in the tropics and strengthens the case for using nature-based solutions to increase resilience and sustainably manage biodiversity.

Mangrove Insurance

In a recently published paper by Mike Beck, AXA's Research Chair in Coastal Resilience, it was calculated that flood risks along 700,000 kilometres of coastline with mangroves, exceed $USD 730 billion annually in direct impacts to property[3]. Globally, mangroves reduce risk to more than 15 million people and prevent more than $USD 65 billion in property damages every year[4]. They do this by blocking storm surge and dissipating wave energy, thus protecting people and structures along the shoreline.

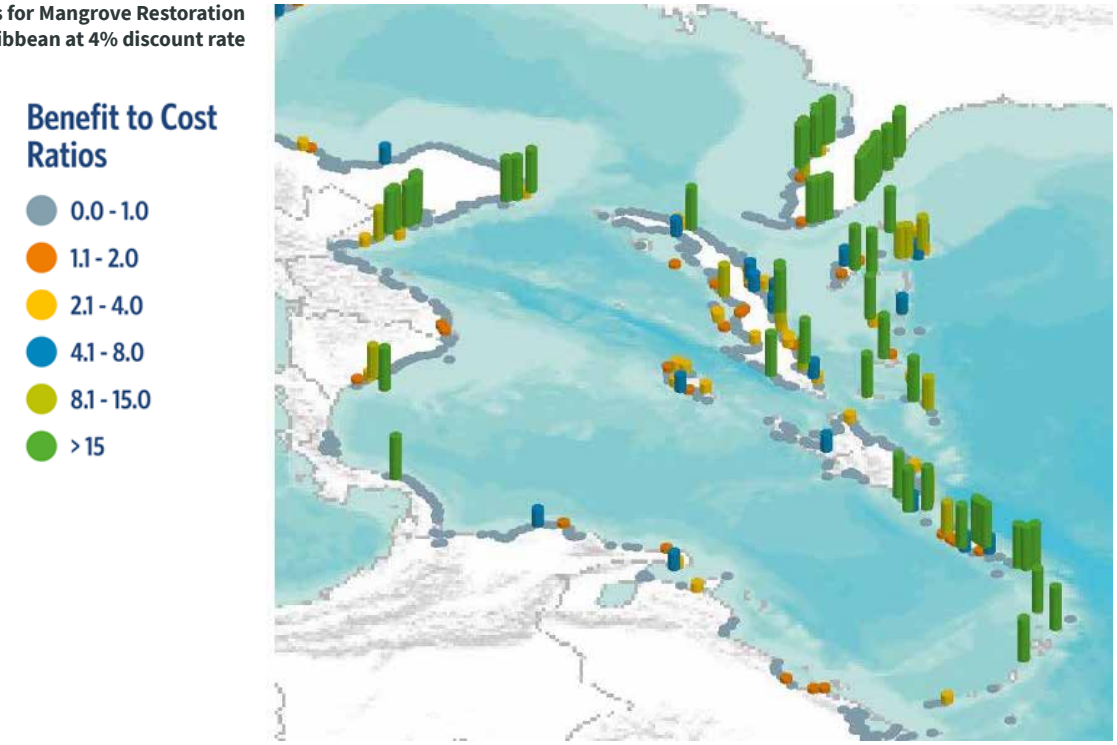
Mangroves also provide socio-economic and ecological benefits including supporting local jobs, maintaining food security, sequestering carbon and promoting biodiversity.

Taking action to protect existing mangrove forests and restore those that could protect coastal communities is paramount to reducing community vulnerability to coastal flooding, which is expected to increase due to rising sea levels.

As such, AXA XL and our partners at The Nature Conservancy and the University of California Santa Cruz, have led the first study into how insurance could cost-effectively help protect and restore mangrove forests following extreme weather events in the Caribbean region. The report calculates the restoration costs and flood reduction benefits of mangroves per hectare. It identified

Continued ➲

Benefit:Cost Ratios for Mangrove Restoration across the Caribbean at 4% discount rate

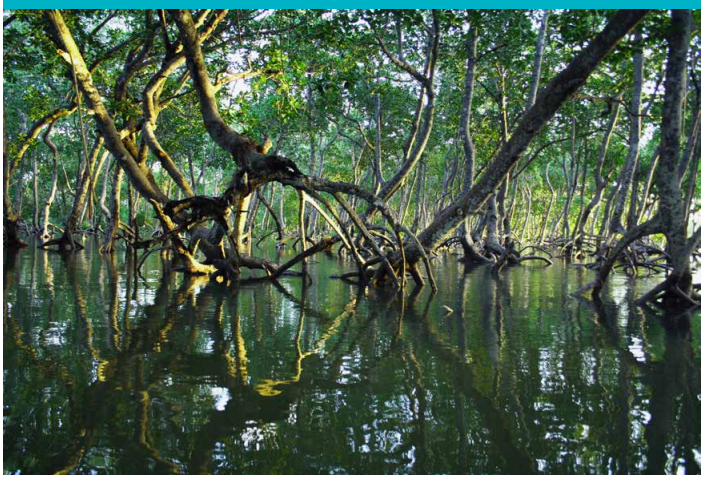


over 3,000 km of coastline, spanning 20 territories or countries, with cost-effective opportunities for mangrove restoration where the development of a mangrove insurance product would be a unique tool to ensure that they continue to provide coastal protection, alongside the socio-economic and ecological benefits.

A follow-up study undertaking a deeper market analysis and to identify the geographies for pilot studies has already begun. It will also construct fragility curves to determine the windspeeds at which mangroves are damaged and their protective benefits are reduced. This information will help to establish the trigger point for potential parametric insurance products.

This science led, nature-based approach, allied with risk management expertise, showcases our leadership in developing innovative products to enhance resilience and promote insurance as a key mechanism for risk reduction.

Globally, mangroves reduce risk to more than 15 million people and prevent more than $USD 65 billion in property damages every year.



References

1 Menendez, P. et al. The Global flood protection Benefits of Mangroves, www.nature.com/scientificreports 2020
2 M.W. Beck, I.J. Losada et al. The global flood protection savings provided by coral reefs, www.nature.com/naturecommunications, 2018
3 https://theconversation.com/protecting-mangroves-can-prevent-billions-of-dollars-in-global-flooding-damage-every-year-132424 from Menéndez et al. 2020
4 Menendez, P. et al. The Global flood protection Benefits of Mangroves, www.nature.com/scientificreports 2020

About the Author

Chip Cunliffe, who has a BSc. Hons Geography, established and manages AXA's Ocean Risk Initiative which works to identify innovative insurance and finance solutions to the impacts and implications of ocean-related risk. He also co-chairs the Ocean Risk and Resilience Action Alliance, bringing together the private sector, governments, the scientific and NGO communities to incentivise investment into nature-based solutions helping to build resilience in vulnerable coastal regions. Chip is based in the UK and can be reached at chip.cunliffe@axaxl.com.

Diversification Of Atmospheric Perils

Climate Research

Innovation is often portrayed as an exciting new product or a new market, some of which we described in other parts of this brochure. However, we should not neglect research as another key strand of innovation. At AXA XL, we partner with a number of academics in a variety of areas, who are helping us to shape some of the innovation which leads to a deeper understanding of the risks that we take on and, ultimately the products and services we deliver to our clients.

Global (re)insurance of atmospheric perils such as floods and tropical cyclones works through the ability to diversify such events internationally. There are however large-scale climate patterns (oscillations) that modulate the dependence between precipitation and temperature over space and time which in turn drives important seasonal changes in atmospheric perils.

To explicitly represent how the spatiotemporal dynamics of the climate system drive atmospheric perils, we have developed global peril models and stochastic catalogues for riverine flood and tropical cyclone wind that are driven by a global climate model. Climate models reflect decades of scientific development in representing the large-scale physics of the atmosphere and ocean. As such, they are the ideal tools to study how climate oscillations in space and time impact the correlations between perils. Focusing on the El Niño Southern Oscillation (ENSO), due to its global-scale impacts and level of predictability, we find a far more nuanced picture of correlations between atmospheric perils and interesting implications for risk management.

Continued ➲

By David A. Carozza and
Mathieu Boudreault
Université du Québec à Montréal

Does Spatial Diversification Imply Risk Diversification?

When we dig into the issue of spatial and risk diversification, it is important to distinguish how a (re)insurance portfolio (exposure) interacts with a natural hazard. One may find that flood hazard is spatially correlated over several other locations but ultimately, the impact on the risk side depends on the company's exposure over these areas. As such, an insurance portfolio can magnify or reduce spatial dependence of a natural hazard.

So, does spatial diversification imply risk diversification? The short answer is no. To measure the effects of spatial diversification on risk diversification, one needs detailed exposure data. This also means that it is possible to potentially reduce the effects of spatial dependence through portfolio optimization.

What is the Level of Correlation that Exists Globally between Regions and Perils?

We have analysed the spatial diversification of riverine floods and tropical cyclones and find that flood occurrence and severity are positively correlated across watersheds that are within 1,000 km, indicating that flood risk is likely not diversifiable within such range. Our research also finds that regions connected to the same cyclogenesis basins (such as the United States and Central America / Caribbean) show strong correlations, meaning that tropical cyclone risk is not diversifiable within a common cyclogenesis basin. This might suggest that floods are diversifiable beyond 1,000 km and that tropical cyclones are diversifiable across cyclogenesis basins.

One may also wonder whether we can diversify across atmospheric perils. We have thus analysed flood occurrence with tropical cyclone winds and found that such dependence appears weak. This might also suggest that diversification across perils, such as European flood with U.S. tropical cyclone perils, is feasible. Our ability to diversify beyond 1,000 km, across cyclogenesis basins or perils is however subject to large-scale climate patterns such as El Niño Southern Oscillation (ENSO). This shows the potential limits to diversification of atmospheric perils, thus emphasizing the importance of controlling a portfolio's exposure.

Does ENSO Affect Correlations and Diversification?

An important question that remains is whether ENSO affects correlations and diversification. For both floods and tropical cyclones, we find systematic and material differences in hazard over different ENSO phases. This is confirmed over a wide variety of regions worldwide and our results are consistent with established ENSO impacts. We further show that if the exposure is as diversified as wealth (GDP), then it is possible to diversify flood risk and reduce the effects of ENSO within a large territory (for example, Canada, Western Europe, or Australia). An important exception is the case of U.S. flood risk, which remains significantly affected by ENSO. Our work thus highlights the importance of differentiating spatial diversification (hazard) from risk diversification, emphasizing the role of portfolio risk management and optimization in controlling the effects of ENSO.

Continued ➲

Fig 1: Difference in flood risk between La Niña years and all years. Risk difference is measured in terms of GDP disrupted ($, pseudo log10) and calculated using 160 000 simulated years.

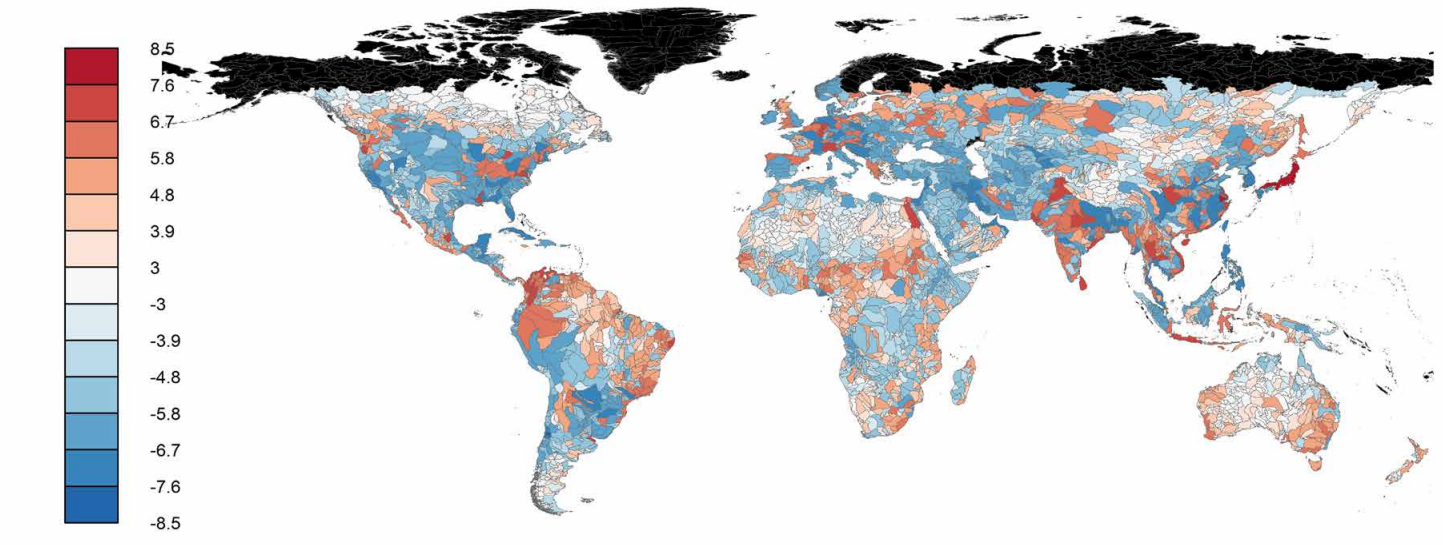
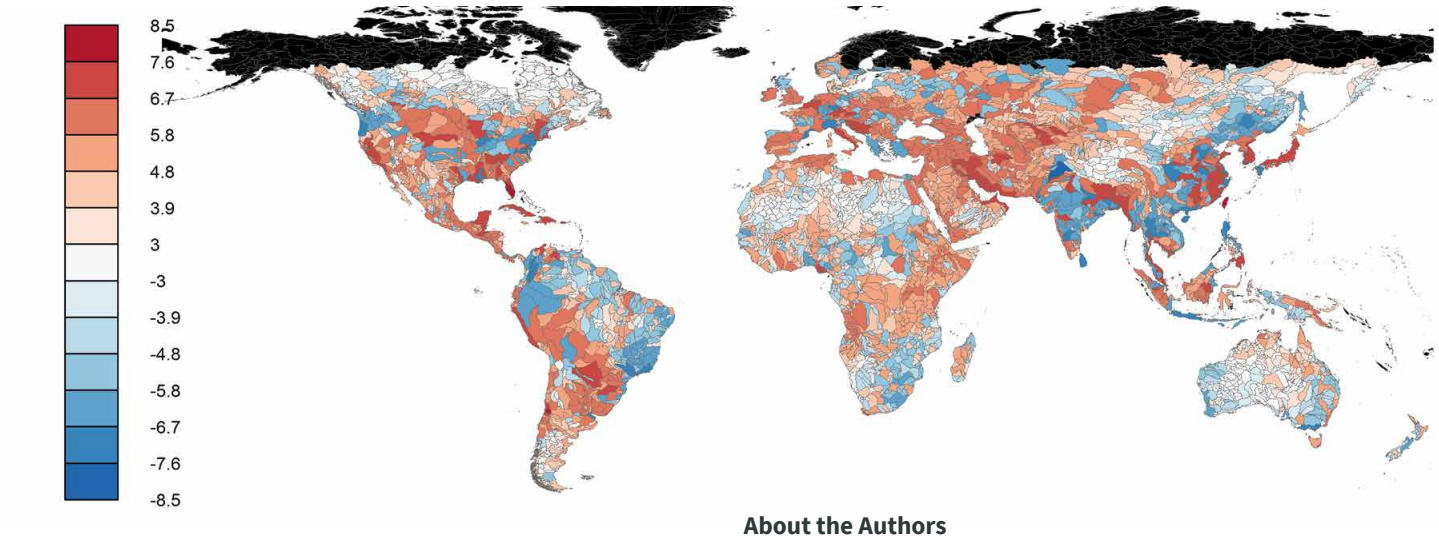


Fig 2: Difference in flood risk between El Niño years and all years. Risk difference is measured in terms of GDP disrupted ($, pseudo log10) and calculated using 160 000 simulated years.



This work will allow us to further develop our understanding of potential impacts of a changing climate, allowing the (re) insurance industry to develop strategies to improve resilience in the face of a changing climate.

How can we manage the influence of ENSO?

ENSO is potentially a systematic risk over a global portfolio but fortunately, it also provides a natural hedging solution. In many regions, we find that ENSO has opposing effects in its cold versus warm phase, meaning that portfolio management should seek to optimize exposure over regions with opposing impacts. ENSO is also a relatively cyclical phenomenon, meaning there are benefits to temporal diversification.

Current and future research

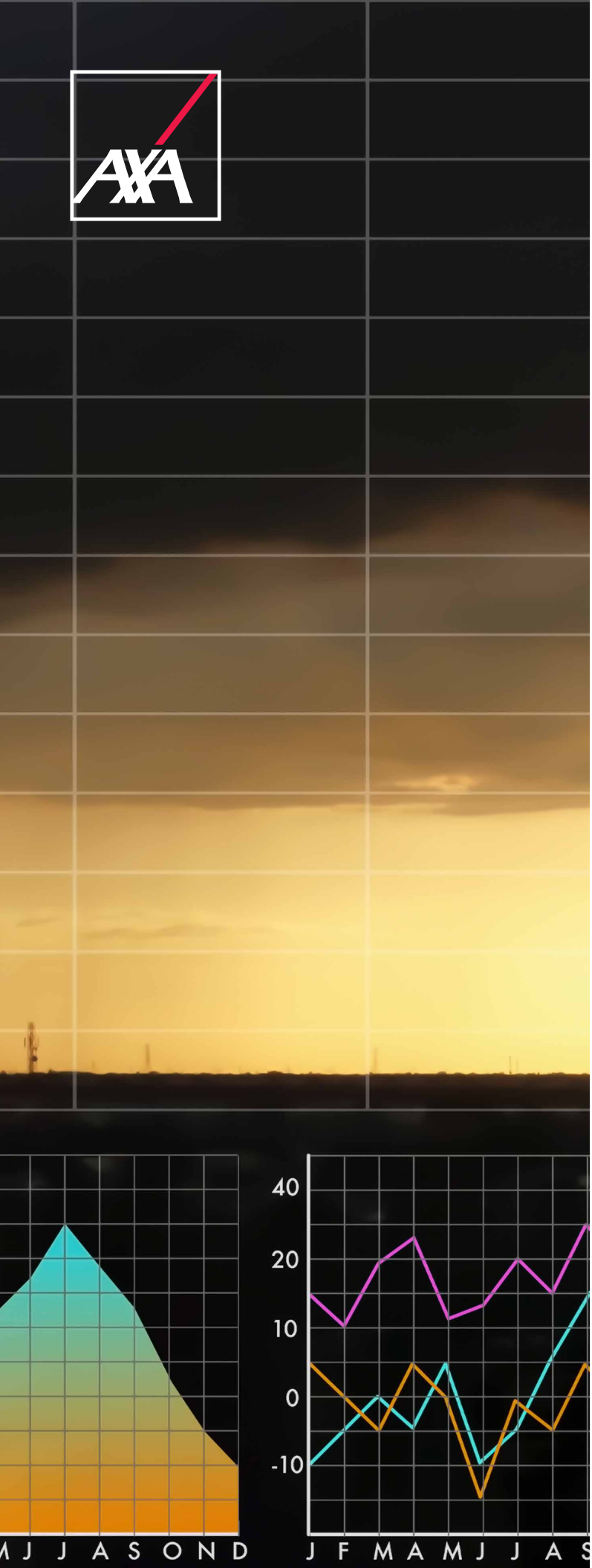
Our work has showed the importance of global climate dynamics on (re)insurance portfolio management. We are currently refining our modelling framework to better integrate local-scale dynamics consistent with higher resolution exposure data. This work will allow us to further develop our understanding of potential impacts of a changing climate, allowing the (re)insurance industry to develop strategies to improve resilience in the face of a changing climate.

About the Authors

David A. Carozza, Ph.D. is a Postdoctoral Fellow in the Department of Mathematics at the Université du Québec à Montréal. He holds a Bachelor's degree in Mathematics from the Université de Montréal with a background in Actuarial Science, in addition to Master's and Ph.D. degrees from McGill University in Atmospheric and Oceanic Sciences and Earth and Planetary Sciences, where he worked on modeling the impacts of climatic change. David is also a Certified Extreme Event Modeler of the AIR Institute. His work has been published in Geophysical Research Letters, Global Ecology and Biogeography, Geoscientific Model Development, PLOS One, and Nature Communications, Nature Geoscience, and Nature Ecology and Evolution, and the Proceedings of the National Academy of Sciences.

Mathieu Boudreault, Ph.D., FSA, FCIA is Associate Professor of Actuarial Science in the Department of Mathematics at the Université du Québec à Montréal (UQAM). He is Undergraduate Chair (Actuarial Science) and former Director of Quantact, the Research Laboratory in Actuarial and Financial Mathematics. In addition to being a Fellow of the Society of Actuaries and of the Canadian Institute of Actuaries, he holds Bachelor's and Master's degrees in Actuarial science and a Ph.D. in Business Administration (Financial Engineering). His research interests include natural catastrophe risk modeling (floods and tropical cyclones), the impacts of climate change in (re)insurance and financial risk-sharing of climate extremes. His work has been published in actuarial and climate sciences in journals such as Journal of Risk and Insurance, Insurance: Mathematics & Economics, North American Actuarial Journal, Journal of Climate, Journal of Geophysical Research and Climate Dynamics.

AXA XL and the Université du Québec à Montréal (Canada) have partnered together since 2017 exploring the impacts of external drivers on diversification and pooling of risks in the field of natural perils. The authors would also like to acknowledge the additional financial support from Mitacs, the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Fonds de recherche du Québec – Nature et technologies (FRQNT).



North Atlantic Hurricane Risk: Counterfactuals

The global (re)insurance industry often uses catastrophe (cat) models to quantify risk arising from extreme events. These models are multi-disciplinary, usually incorporating scientific, engineering and economics-based modules that combine to produce risk probabilities and subsequent loss estimates. The extreme events of interest to cat modelling are, by definition, rare. Thus, quantifying the risk of the impacts of these events in a statistically robust manner is extremely difficult.

Contemporary cat modelling attempts to appropriately quantify the risk of these events by taking a relatively sparse historical record, and applying stochastic methods to generate a much larger, artificial dataset to help better inform decision makers. One of the largest limitations of these stochastic-set methods is that the statistics of the underlying dataset are, to at least some extent, preserved. Thus, any biases from an under-representative historical record may be incorrectly reinforced.

The HURDAT2 (historical record for North Atlantic Hurricanes) (NAHUs) is unique in length and detail for extreme weather perils; in its current format, it ranges from 1851-present, and provides (among other things) estimates of geolocation, central pressure and maximum sustained surface (10m) windspeed for the vast majority of storms in its record. Although quite remarkable and valuable, the dataset is known to be rife with uncertainty, particularly in the years before the dawn of the satellite era (Landsea & Franklin, 2013)[1]. Any single stochastic dataset that is created from it will be subject to uncertainty.

The advent of climate reanalysis simulations, which utilise contemporary climate modelling techniques but run through periods of history, has increased the completeness and reliability of historical records for many climate and weather perils, but the

Continued ➲

By Catherine Pigott and John Wardman

methods are far from perfect, particularly for extreme events. For example, Befort et al. (2016)[2] showed how the use of different reanalyses would lead to different conclusions about long-term trends in EU Windstorm activity in the pre-satellite era. On top of this, in the case of North Atlantic Hurricane (NAHU) specifically, the existing reanalysis projects also don't run as far into history as the raw HURDAT2 (Hurricane data set) observational record. As a result of these issues, it is widely recognised within the cat modelling community that contemporary methods for quantifying risk from NAHUs (and any other extreme weather peril) may be misrepresentative of the true risk of the peril. A question therefore arises: can we utilise techniques employed in other areas of cat modelling or climate and weather forecasting/modelling in order to better understand risk from NAHUs? It is with this question in mind that we come to the topic of counterfactual risk analysis.

Working with academics at the University of Exeter and University of Reading, AXA XL have embarked upon an exercise to explore the use of historical, dynamical, ensemble forecast data to create a suite of alternative histories. The assumption within the stochastic cat modelling process is that the observed historical record accurately represents the mean of possible outcomes. We are testing this assumption by looking to compare alternative, but realistic, histories to that which we have observed. What if the hurricanes we have observed had taken a different, but realistic course? Our objective is to explore where our observed history sits in a distribution of alternative histories and so to assess potential deviations from the mean but also look at both tails of the distribution.

This is a first step into a different way of thinking about history. If successful and insightful, AXA XL hopes to extend this work outside of USHU to other tropical cyclone basins around the globe.

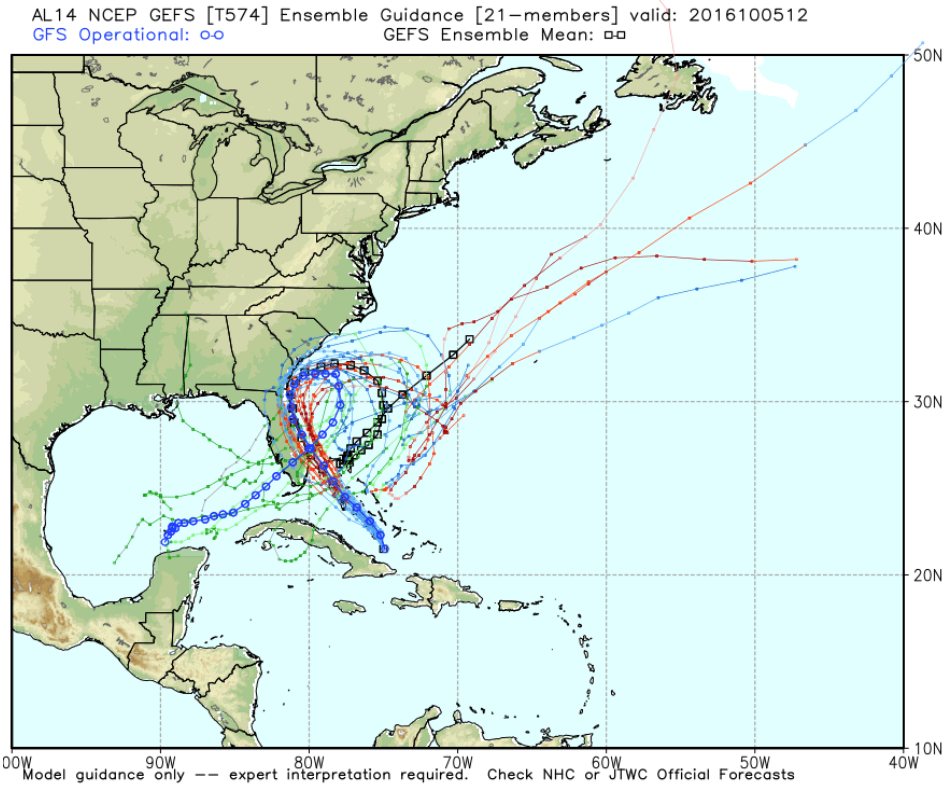


Figure: Hurricane Matthew skirted along the Floridian coastline in 2016. The actual observed path is shown in blue with alternative predictions by National Centers for Environmental Protection (NCEP) also shown.

References

1 Landsea, C. W., & Franklin, J. L. (2013). Atlantic hurricane database uncertainty and presentation of a new database format. Monthly Weather Review, 141(10), 3576-3592.

2 Befort, D. J., Wild, S., Kruschke, T., Ulbrich, U., & Leckebusch, G. C. (2016). Different long‐term trends of extra‐tropical cyclones and windstorms in ERA‐20C and NOAA‐20CR reanalyses. Atmospheric Science Letters, 17(11), 586-595.

About the Authors

Catherine Pigott has a BSc. Mathematics and FIA. She leads AXA XL's divisional Science & Natural Perils team, which is responsible for driving applied scientific research and academic collaborations within AXA XL. The team are also responsible for third party cat model evaluations, cat model development and cross segment portfolio analytics in the area of natural perils within the division. Catherine joined AXA XL, previously Catlin, in 2009 as the Business Group Actuary for Short Tailed Treaty lines and has held several positions since then, predominately focusing on catastrophe exposed business. Catherine is based in the UK and can be reached at: catherine.pigott@axaxl.com.

John Wardman, PhD, FGS, is a Senior Specialist on the AXA XL Science & Natural Perils Team where he helps to build and inform views of catastrophe risk, assist CAT model evaluation and validation, and support product development. John's role also includes engaging with scientists and university departments from around the world, facilitating the translation of academic research into business impacting information and data. John is based in the UK and can be reached at: john.wardman@axaxl.com.

Predicting Structure Loss from Wildfire

Many of the conditions which facilitate large and high-intensity wildfires are not necessarily conducive to structure (i.e. insured) loss, and this has been a considerable drawback of existing wildfire risk models. Wildfire structure-losses in the hundreds to thousands of units is a relatively new trend in the US and globally. In California, and prior to 2000, extensive structure-losses occurred on relatively isolated events, such as the 1970 Laguna Fire (382 structures) and the 1990 Painted Cave Fire (427 structures), both in Santa Barbara County along the southern coast of California. As these losses were considered relatively isolated and infrequent, there has been little interest in trying to improve prediction of structure loss. Further, as with natural disasters more broadly, quantifying the vulnerability of structures to wildfire in order to characterise risk is a function of interacting predictors at multiple spatial and temporal scales.

Catastrophic (i.e. structure-loss) risk from wildfires is generally dependent upon four groups of factors: structural construction, fuel composition and arrangement around the structure, fuel availability/flammability as a function of climate and weather variables, and human factors (see below). The likelihood of structure-loss is dependent upon each of these, but they are not all easily quantifiable.

Trying to model future structure-loss given the incompatibility between the three spatial scales, the lack of accurate data at finer scales, and the significant influence of random human factors makes it exceedingly difficult to do so. Further complicating such efforts is that probability of structure-loss is conditional upon a wildfire ignition, which is also difficult to predict with high accuracy.

Continued ➲

By Catherine Pigott and John Wardman

FINE SCALE: Structural construction
- Materials (roofing, siding, windows, doors, decking)
- Potential for ember intrusion (attic vents, unenclosed eaves, gutter, roof joints, chimneys)
- Home living components (flags, flower pots, benches, toys, outdoor furniture, wood piles)

MODERATE SCALE: Fuel composition and structure
- Landscaping (ground cover, irrigation, fencing, wood features, flammability of plant vegetation)
- Surrounding fuel matrix (native vegetation composition, community landscaping, neighboring home composition)
- Topography (slope, aspect, topographic position)

COARSE SCALE: Climate/weather factors control fuel availability)
- Climatology determining fuel composition and fire season
- Climatological anomalies (drought, El Niño, Southern Oscillation, pluvial conditions)
- Meteorology during fire (temperature, moisture, wind)

HUMAN FACTORS (not measurable)
- Maintenance of structure and landscaping
- Condition of structure when evacuated (eg, were doors and windows all shut?)
- Fire suppression actions taken (eg, retardant drop, fire engine with water present)

Figure 2: Major factors known to affect structural survival and loss during wildland fires

Recent development of structure-loss datasets both nationally and in California has facilitated new research in this area to better understand predictors of structure-loss from wildfires. Both Syphard and Keeley (2019)[1] and Alexandre et al. (2016)[2] found it difficult to predict the factors contributing to structure-loss, with both noting limits to the data available and problems with data interpretation. Further, both efforts make key inaccurate assumptions likely based on lack of field observations of structure-loss fires. Their difficulties in developing predictive models, however, serve to inform the research directions at AXA XL. Also, collaborative partnerships with experts from the Leverhulme Centre for Wildfires, Environment and Society, the Insurance Institute for Business and Home Safety and the University of California, Merced exemplify our commitment to implementing the best science when developing views of wildfire risk.

References

1 Syphard, A. D., Rustigian-Romsos, H., Mann, M., Conlisk, E., Moritz, M. A., & Ackerly, D. (2019). The relative influence of climate and housing development on current and projected future fire patterns and structure loss across three California landscapes. Global Environmental Change, 56, 41-55.

2 Alexandre, P. M., Stewart, S. I., Keuler, N. S., Clayton, M. K., Mockrin, M. H., Bar, Massada, A., ... & Radeloff, V. C. (2016). Factors related to building loss due to wildfires in the conterminous United States. Ecological applications, 26(7), 2323-2338.

About the Authors

Catherine Pigott has a BSc. Mathematics and FIA. She leads AXA XL's divisional Science & Natural Perils team, which is responsible for driving applied scientific research and academic collaborations within AXA XL. The team are also responsible for third party cat model evaluations, cat model development and cross segment portfolio analytics in the area of natural perils within the division. Catherine joined AXA XL, previously Catlin, in 2009 as the Business Group Actuary for Short Tailed Treaty lines and has held several positions since then, predominately focusing on catastrophe exposed business. Catherine is based in the UK and can be reached at: catherine.pigott@axaxl.com.

John Wardman, PhD, FGS, is a Senior Specialist on the AXA XL Science & Natural Perils Team where he helps to build and inform views of catastrophe risk, assist CAT model evaluation and validation, and support product development. John's role also includes engaging with scientists and university departments from around the world, facilitating the translation of academic research into business impacting information and data. John is based in the UK and can be reached at: john.wardman@axaxl.com.

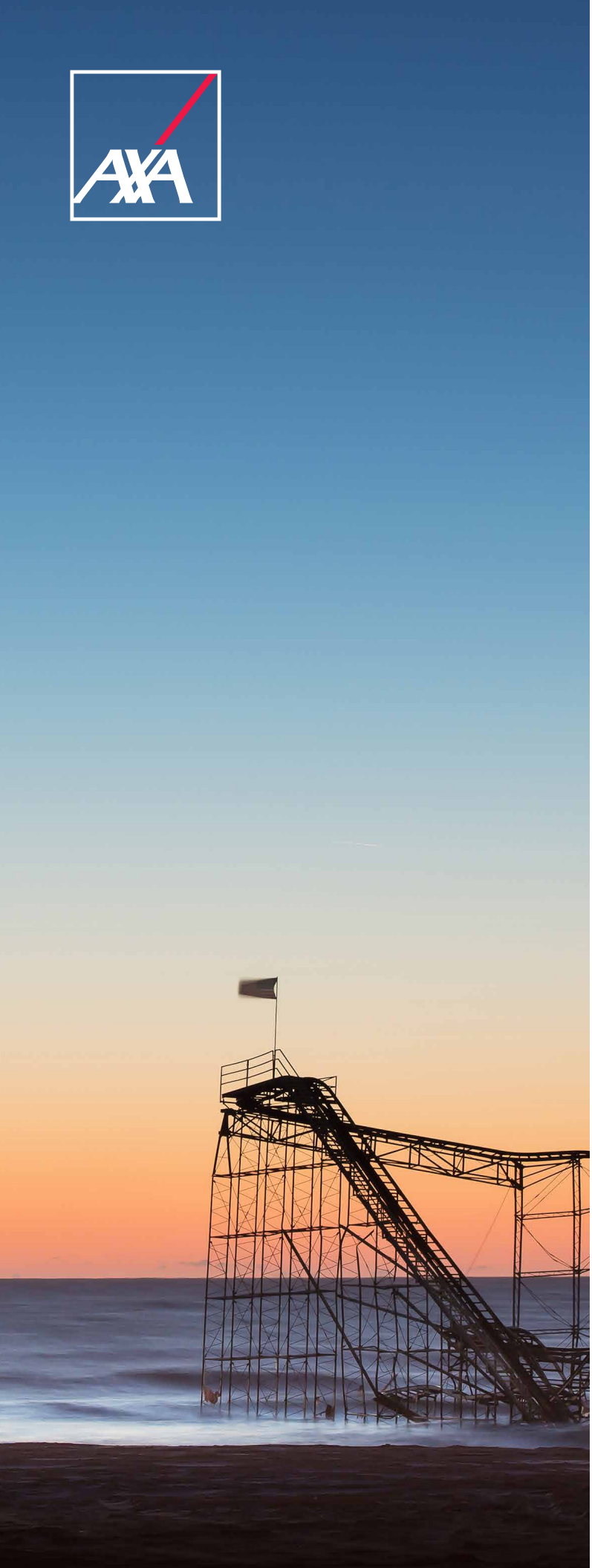
Collaboration and Protection

How we and our industry, with a focus on present and future climate issues, are helping our clients build back better and build better before

Optimising Disaster Recovery:
To Act for Human Progress by Protecting What Matters

Addressing Climate Risk with Public Private Partnerships

Our Corporate Social Responsibility (CSR) Strategy



Optimising Disaster Recovery: To Act for Human Progress by Protecting What Matters

Our Work with Cambridge Centre for Risk Studies

Putting communities impacted by disasters back on their feet as quickly as possible, and in a better state, is just one example of how we make AXA's purpose to 'act for Human Progress by protecting what matters' a reality. The case for (re)insurance is clear but is seldom adequately explained. Below is a link to a video that captures our collaboration with the Cambridge Centre for Risk Studies ("CCRS") at Cambridge Judge Business School, which has released a comprehensive report demonstrating the impact that (re)insurance has on the speed and quality of recovery following natural disasters. We trust that you will find it very informative.

▷

Play Video

A few facts from the report stand out:

- Each percentage point of insurance penetration (non-life premiums divided by a country's GDP) reduces recovery times by almost a year

- Events in countries with high insurance penetration (3% - 4% includes Western Europe, Japan, Australia, South Korea) have an average recovery rate of less than 12 months and events in countries with very low insurance penetration take more than 4 years

Continued ➲

By Cambridge Centre for Risk Studies at Cambridge Judge Business School and Andrew MacFarlane

- The US is anomalous – the US enjoys very high insurance penetration (>4%) but the fragmented nature of coverage, particularly flood, disaster response and scale of loss have resulted in a recovery rate of just over 3 years (Hurricane Andrew, Great Mississippi and Missouri Floods, Northridge, Katrina, Sandy).

- The quality of recovery for countries with high and very high insurance penetration is sometimes better than pre-loss levels, whereas the reverse is often true for those countries with lower insurance penetration. There is potential for product development in terms of trying to ensure that products allow for "Build Back Better" as part of their terms ensuring that properties rebuilt are done to a more resilient standard than previously.

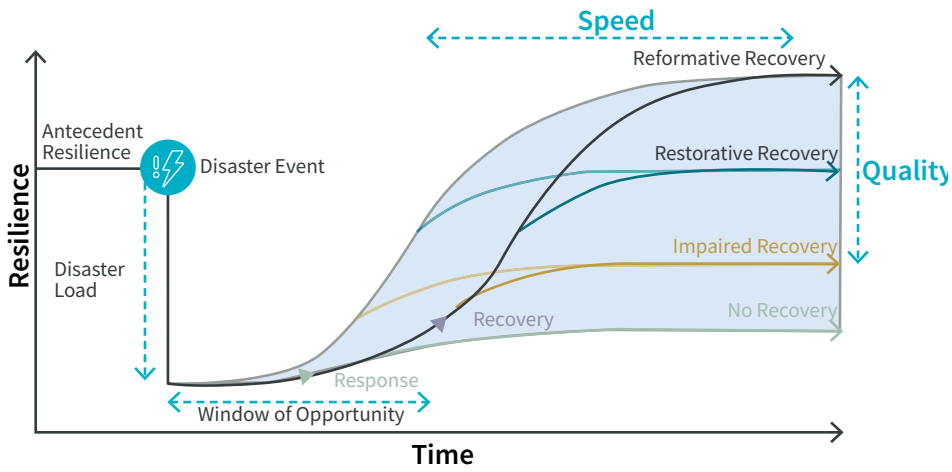
- Economic recovery is faster than societal recovery in almost 60% of the cases, being particularly pronounced in the first 6 months. For example; in 2013 after the floods in Germany, affecting more than 600,000 people and displacing 80,000, there was recovery to "societal norms" within 12 months. Contrast this with the earthquake in Haiti in 2010, from which the country has never fully recovered.

- Speed and quality of recovery are not mutually exclusive – CCRS have identified several cases satisfying both outcomes.

References

1 http://david-lallemant.com/building-post-disaster-resilience/

Figure 1: Conceptual Framework of recovery as a process of building resilience. In this context, disaster risk reduction in the recovery process means having a steeper trajectory (faster recovery) and a higher eventual outcome (more resilient). (Adapted from Lallemant 2013)[1]



About the Authors

Andrew MacFarlane has a BSc. Hons Actuarial Science & Statistics and FIA. He is Head of Pricing & Analytics for London & Bermuda for Reinsurance at AXA XL and a Partner on AXA XL's Leadership Council. In his Head of Pricing & Analytics role he manages the actuarial team across London and Bermuda supporting underwriters across a broad range of business lines and products. Andrew was involved in setting AXA XL's CSR strategy and is a member of the AXA XL CSR Steering Group. Andrew plays an instrumental role in looking to expand AXA XL's involvement in closing the protection gap and leads the Public Sector Partnership practice group at AXA XL. The aim of the group is to strengthen partnerships with the public sector in order to bring socially impactful insurance solutions to the market. Andy is based in Bermuda and can be contacted at: andrew.macfarlane@axaxl.com.

Cambridge Centre for Risk Studies

The Cambridge Centre for Risk Studies is based within the University of Cambridge Judge Business School. The Centre works closely with business partners in tackling complex issues of management science in risk. This policy of deep engagement has enabled the Centre to develop relevant solutions for businesses. The Centre's leadership combines academic excellence with industry experience.
Further information on CCRS's risk management resources can be viewed at cambridgebusinessriskhub.com.
For further information please contact:
Suzanne Hopkins, Senior Advisor, Cambridge Centre for Risk Studies
s.hopkins-oldak@cantabrisk.com

Addressing Climate Risk with Public Private Partnerships

At AXA XL, we strongly believe that insurance has a key role to play in increasing the resilience of communities to climate related hazards, globally. In developing countries, insurance not only provides a safety net for people, businesses and governments, but can also help protect development gains and stabilize economies. Given the size of the challenge, collaboration between the private and public sectors is critical to accelerating and scaling up these efforts with concrete action.

For AXA XL, a key part of driving greater use of insurance to address the challenge and opportunities of climate change is through our active engagement in the Insurance Development Forum (IDF).

IDF

First announced in 2015 at the Paris COP21 Climate Summit by Mike McGavick, then CEO of XL Group Ltd, the IDF is an industry-led public-private partnership supporting the growth and development of insurance-related resources and capabilities to help achieve the objectives of the Sustainable Development Goals (SDGs) and related U.N. Agreements of 2015-2016 (Sendai - Disaster Risk), Addis Ababa (Finance for Development), Paris (Climate) and Istanbul (Humanitarian System), collectively known as the U.N. Global 2030 Agenda. As the first insurance industry led public-private partnership, the IDF was conceived and proposed by the Political Champions Group for Disaster Resilience (PCG) during the 2013 UN General Assembly.

The IDF is currently chaired by Denis Duverne, Chairman of AXA, representing the (re)insurance industry, and co-chaired by Achim Steiner, United Nations Development Program (UNDP) Administrator, and Hiroshi Matano, Executive Vice President of MIGA - Multilateral Investment Guarantee Agency, World Bank Group.

Continued ➲

By Claudia Thyme

The non-profit organization aims to optimise and extend the use of insurance and its related risk management capabilities to build greater resilience and protection for people, communities, businesses, and public institutions that are vulnerable to disasters and their associated economic shocks.

It enables (i) the optimal coordination of insurance-related activities; (ii) the development of shared priorities; (iii) the mobilization of resources; (iv) the promotion of strategic and operational relationships within and between governments, industry, and international institutions; and (v) safeguards the integrity and effectiveness of joint efforts and collective resources. Five dedicated working groups drive the IDF's programmes and initiatives: i) Sovereign & Humanitarian Solutions (SHS); ii) Risk Modelling & Mapping Steering Group (RMSG); iii) Law, Regulation & Resilience Policies (LRRP); iv) Inclusive Insurance and v) Investments.

The Role of AXA XL within the IDF

In the role of Industry Deputy Chair of the Sovereign & Humanitarian Solutions (SHS) working group, AXA XL is contributing to drive and coordinate efforts across industry and public sector members. A strong focus of the SHS activities is the *Tripartite Agreement* which IDF signed with the German Federal Ministry for Economic Cooperation and Development (BMZ) and UNDP in September 2019, during the UN Secretary General's Climate Summit in New York.

The Tripartite Agreement looks to amplify the strengths of the various parties and to scale-up the use of risk financing mechanisms to deliver on global resilience and adaptation ambitions. Under the agreement, IDF commits to deliver climate and disaster risk modelling, technical assistance and risk transfer solutions to 20 climate vulnerable countries by 2025 working closely with UNDP local offices, and to provide USD 5 billion in risk capacity for climate risk insurance in the same period. The solutions will be delivered as projects led by the insurance industry members of its SHS working group, who will co-finance the projects in-kind.

As a strategic partner, BMZ funds 50% of the value of the projects through the InsuResilience Solutions Fund (ISF).

The Peru Public Schools Project

AXA XL is also co-leading the first Tripartite IDF project, to design an insurance solution for Peru's public schools. The project will provide the Government an insurance programme that protects public schools against the impact of natural disasters with indemnity or parametric insurance solutions, or a combination of the two. It aims to improve continuity for children's education by accelerating reconstruction, while also strengthening the country's resilience.

AXA XL leads the consortium created to implement the project, which includes Munich Re as an IDF co-lead, the Peruvian Association of Insurance Companies (APESEG) as initiator of the project, as well as risk modelers GEM Foundation and JBA Risk Management and the InsurTech Picsure.

The project includes the delivery of flood and earthquake risk models to the Government on an 'open source' basis, as well as training sessions for Government teams to strengthen risk understanding and ownership and enable a broader risk management approach. A *Build Back Better* element aims to increase the resilience of Peru's schools over time. The project also specifically proposes an ex-ante procurement process for reconstruction and the use of image capturing technology which, supported by geocoding and artificial intelligence, enables better documentation of the assets to be insured, as well as initial documentation and estimation of damages after an insured event. This innovative technology can accelerate the underwriting and claims management processes and also help avoid fraud.

Delivering concrete solutions to address climate change by strengthening disaster risk mitigation efforts and increasing resilience is at the core of IDF's mission. This is why contributing our technical expertise to its efforts is a key priority for AXA XL.

About the Author

Claudia Thyme holds a BS from Georgetown University, Washington D.C., an MBA from City University London Business School and a Certificate from the Academy of Behavioral Economics/ GDI. She is VP, Director Strategic Market Development at AXA XL. Claudia promotes and drives the use of disaster risk financing and insurance to increase countries' resilience and protect their development gains. She is also a member of the Operating Committee of the Insurance Development Forum/ IDF, and Industry Deputy Chair of its Sovereign & Humanitarian Solutions Working Group. Claudia is based in Zurich and can be reached at claudia.thyme@axaxl.com.

Our Corporate Social Responsibility (CSR) Strategy

AXA XL's 2019-2021 CSR strategy is aligned to key issues that are pertinent to our business: climate change, access to water and financial resilience.

Climate: Companies and communities face a number of climate-related risks. We're reducing our carbon footprint, protecting ecosystems and exploring how our business can help build a better world.

Water: Access to water is expected to be an increasing challenge – and not just in developing countries. The United Nations predicts a 40% shortfall in the global water supply by 2030. We're developing efforts to improve water security where it is – and will be – needed most.

Financial resilience: We're in the business of making our clients financially futureproof. We can do the same for our local communities. We're helping create opportunities for the unemployed and underemployed, so they can be better prepared for unexpected changes.

Our strategy supports AXA's Purpose: *To act for human progress by protecting what matters.*

Our Climate Actions

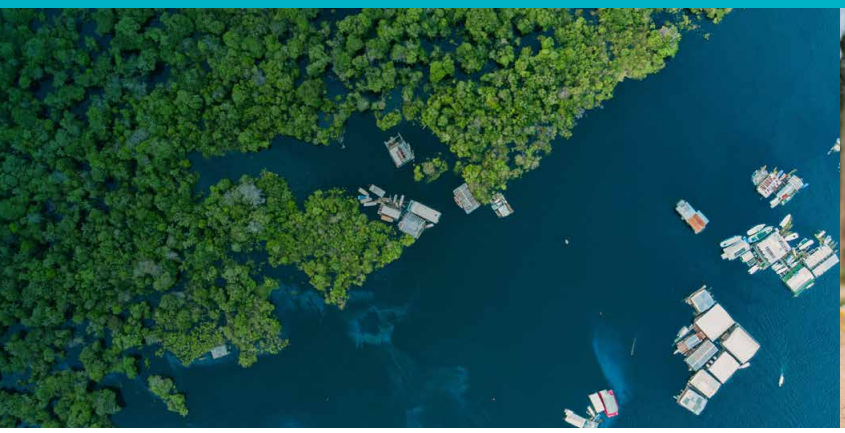
Creating a blue carbon future

Significant areas of the world's coastlines are lined with mangroves, seagrasses and tidal marshes – all of which represent major carbon sinks, capturing and storing billions of tons of carbon from our atmosphere. These coastal wetland ecosystems do this at rates up to five times greater than terrestrial forests, highlighting their vital importance.

Continued ➲

By Suzanne Scatliffe

AXA XL's CSR strategy is aligned to key issues that are pertinent to our business: climate change, access to water and financial resilience.



The stored carbon is referred to as "blue carbon," and it can remain in the soil for thousands of years, making it one of the longest-term natural solutions to climate change.

Not only do these coastal wetlands help to mitigate against climate change, they also offer protection against storms by absorbing incoming wave energy, often at lower costs than built infrastructure like seawalls and levees. Global environmental nonprofit The Nature Conservancy (TNC) has conducted research that illustrates how nature-based coastal resilience can save communities hundreds of millions of dollars when severe weather strikes, reducing flood damage by decreasing wave energy by up to 66%.

According to TNC, half of the world's population lives in coastal areas, making sea-level rise and impacts from changing nature of storms a significant climate-related risk. The conservation and restoration of coastal wetlands can help protect millions of people while providing many other benefits such as enhanced biodiversity, healthier fisheries, water purification and improved local livelihoods.

Despite the numerous benefits these habitats provide, scientists estimate that 50% of the world's mangroves and seagrasses, and at least 25% of tidal marshes, have been lost. It is critical that the world's blue carbon systems are protected and restored now.

In 2019, we continued our partnership with TNC by assisting in the creation of a groundbreaking investment product: Blue Carbon Resilience Credits.

These would, for the first time, value the combined carbon sequestration and resilience benefits provided by coastal wetland ecosystems. The development of blue carbon credits will tap into the carbon credit marketplace that has traditionally focused on terrestrial credits and enable carbon finance to support these critical habitats over the long term. The resilience credit, purchased with the blue carbon credit or separately, will quantify and invest in the added risk reduction benefits of shielding coastal communities from the changing nature of natural disasters in the future, conserving and restoring our natural ecosystems to their full potential.

TNC is working with the world's leading carbon offset advisory firm TerraCarbon to finalize an assessment of the blue carbon sequestration value of mangrove, marsh and seagrass sites best positioned to generate the first round of the Blue Carbon Resilience Credits. TNC is advancing work in Virginia, Florida and the Northeast U.S., as well as in Chile, Belize and the Caribbean. This work will, we believe, enable businesses like our own to offset their carbon footprint while helping reduce flood risk in some of the most vulnerable areas at the same time as contributing to SDGs 13 (Climate Action) and 15 (Life on Land).

The overlap between the potential opportunity of mangrove insurance with the ability to provide blue carbon credits from mangroves demonstrates the importance of biodiversity in the ecosystem in which we live and the potential opportunities that could emerge in the need to protect them.

Continued ➲

Contributing to water security
AXA XL recognizes the importance of access to clean water in ensuring a safe and healthy future for all and the need to focus on finding innovative solutions for water security. As part of our efforts to improve water resilience around the world, AXA XL has entered into a three-year partnership with international nonprofit WaterAid to bring clean drinking water to more than 10,000 people in rural India.

WaterAid strives to provide clean water, sanitary toilets and improved hygiene to the millions of people still living without these basic human rights.

According to WaterAid, over 94 million people are without clean water in India today, and nearly 732 million do not have access to a sanitary toilet. Our three-year partnership focuses on the district of Fatehpur in Northern India.

Fatehpur is a water-scarce district, which affects the whole community, including its schools. Most schools primarily have non-functioning toilets and limited hand-washing facilities. Additionally, most of the drinking water available to these schools comes through direct hand pumps, which may not be treated before being consumed. WaterAid also discovered that less than 10% of households in the rural parts of the district have access to pipe water supply.

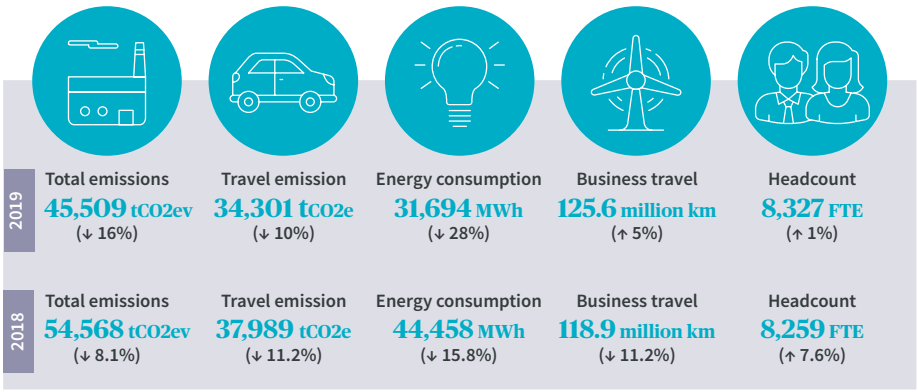
AXA XL's funding will support WaterAid in ensuring improved access to clean drinking water and sanitation facilities in the selected villages of the Fatehpur district; community-based committees that are trained and accountable for sustained drinking water and sanitation facilities; and promoting hygiene behavior change at both a community and institutional level.

Developing sustainable client offerings
We are currently exploring how we could do more as an insurer to manage post-loss waste more sustainably, enabling a "circular economy" through our claims processes. We are researching the current picture for insurance-related waste to understand types of waste materials, current landfill volumes, and the monetary and carbon value of this waste, as well as existing waste processing infrastructure and regulation. This research could help us create an AXA-wide offering for commercial and personal lines customers, in multiple lines of business.

The impacts of climate on water scarcity are also increasing. Access to water is a significant issue for clients in multiple industries, from retail to resource extraction. It is a growing risk for organizations that have operations, customers, or employee bases in areas that may become water scarce. Water crises were once again named among the top 10 global risks in the World Economic Forum's Global Risks Report with respect to both impact and likelihood to occur. We are developing ways to help our clients become more water-resilient through the establishment of our Water Advisory Group, consisting of industry clients, policymakers and academia, as well as colleagues from AXA XL.

Mitigating drought risk
AXA XL is funding research to explore ways drought risk can be better managed in the most vulnerable communities. The research is being conducted by Pennsylvania State University and centers on identifying a way to calculate livelihood-specific weather indices that could be used in resilience programming, focusing on a case study of rainfall-driven hazards in Somalia.

In 2019, we achieved significant emissions reductions compared to 2018 (-16%)



Somalia is a country particularly at risk from rainfall-related hazards, with communities facing the intersection of multiple weather hazards and limited coping strategies. It has suffered from multiple humanitarian crises, including those driven by droughts that were all forecast by meteorologists.
One of the main priorities for the research is to improve the ability for vulnerable communities to robustly assess how climate factors influence current local weather hazards such as too little rainfall and the subsequent drought.

Additionally, a priority is to be able to use this climate information more thoroughly in resilience programming in order to reliably identify new norms under a changing climate, and in turn forecast for these norms.

Training local humanitarian agencies on climate disaster risk reduction

We are partnering with RedR, an international capacity-building nonprofit, to better prepare vulnerable communities for when disasters hit. In 2019, RedR developed a climate change adaptation and disaster risk reduction (CCDRR) course for humanitarian organizations working in vulnerable communities. So far, RedR has trained more than 35 humanitarians in the Philippines, who have passed on their awareness and knowledge about how to prepare for climate-related disasters to more than 800 individuals. The training aims to equip these vulnerable communities to better prepare and recover from climate related disasters.

Managing our carbon footprint

We are continuously striving to reduce our carbon footprint, taking steps to save energy, reduce waste and adopt greener behaviors at work.

We calculate our annual carbon footprint using a full year of collected data (January–December) and report on this the following year. AXA XL has a clearly defined internal protocol, which is reviewed annually to ensure that any business changes are noted for the reporting period.

In 2019, we achieved significant emissions reductions compared to 2018 (-16%). This has mainly been delivered through decreases in emissions from air travel and energy consumption. The trends follow a similar reduction trajectory at a regional level. There has been an increased emphasis on improving the data quality this past year, which has contributed in part to decreases reported by AXA XL; however, there is still room for further improvement to reduce year-on-year data volatility at key sites.

Avieco (formerly Carbon Smart) was commissioned to independently verify 100% of our greenhouse gas (GHG) emissions to a limited level of assurance, as defined by the standard ISO 14064 – part 3. An agreed materiality threshold of 5% at emissions source, and/or global emissions level was applied.

In September 2020, we launched our first Carbon Reduction strategy, focused on saving energy, reducing waste, as well as helping our colleagues adopt greener behaviors while working.

With all the efforts mentioned it is clear the importance that CSR has within the way we operate, not only providing help to communities but also using this as an incubator in terms of thinking of innovative ideas that we can develop into risk transfer solutions that will advance human progress by protecting what matters.

About the Author

Suzanne Scatliffe is Director of Corporate Social Responsibility (CSR) at AXA XL, where she leads the global CSR/sustainability strategy and programs. She has 16 years' experience in CSR roles in the insurance, technology, and education sectors, and is a certified Sustainability Practitioner (IEMA) and Fellow of the Institute of Corporate Responsibility and Sustainability (ICRS). She also serves as Chair of the Board of Directors of the Insurance Industry Charitable Foundation (IICF) UK and volunteers as a Heart of the City Mentor, helping small businesses in the UK develop CSR initiatives. Suzanne is based in the UK and can be reached at suzanne.scatliffe@axaxl.com.

axaxl.com

axaxl.com/climate-risk