Torrent
TECHNOLOGIES, INC

INSIGHTS | AUGUST 2020

2020 State of Flood Report

Actions for a More Protected and Resilient Planet

MARSH

CONTENTS

Close the Gap

An estimated **85%** *of Americans are without flood insurance.*

Flood, already one of the world's most frequent perils, is causing more severe losses, according to data from the Federal Emergency Management Agency (FEMA). We cannot prevent weather conditions that result in floods. But we can apply innovative insurance solutions, resilience planning and execution, fresh technologies, and new processes to better understand and evaluate flood risk with the aim of mitigating the loss of life, property damage, and economic disruptions caused by floods.

Many individuals and businesses around the country are suffering the financial repercussions of the ongoing COVID-19 pandemic. Another blow in the form of a natural disaster could lead to financial ruin. This is why it's essential to ensure a clearer understanding of flood risk at the individual property level, regardless of location or map line.

In doing so, the insurance industry can offer solutions to mitigate and protect property. We need to use data and technology to mitigate this growing risk through raising awareness of how floods will affect where people live in the future, thoughtful urban development, building codes, managing rising sea levels, partnering with government agencies and first responders, and financing mechanisms, such as insurance.

But flood risk is not a problem that insurance alone can solve; it requires coordinated resiliency efforts involving the public and private sectors, similar to what has been accomplished in the UK with the recent adoption of a Property Flood Resilience Code of Practice.

In the past four years, flood-related losses from a string of catastrophic events — including 2017's terrible trio of hurricanes, Harvey, Irma, and Maria, and the Mississippi River floods in 2019 — have shown that insurance plays a vital role in helping individuals, businesses, and communities recover from disasters. There is an urgent need for more flood insurance protection in the US. With Harvey, it is reported that only 17% of homeowners in the eight counties most affected by Hurricane Harvey were protected by flood insurance. Data suggests only 15% of Americans have a flood insurance policy, leaving an alarmingly large percentage of consumers exposed to flooding without protective coverage.

Perhaps one of the biggest reasons for this flood insurance gap is an underestimation of flood exposure. In fact, floods happen nearly everywhere. Between 1996 and 2000, 99% of US counties were impacted by a flooding event. Since 2000, presidential declarations of flood disaster have been made in all 50 states, with 90% having been affected by more than one. Probabilistic modeling released by the nonprofit research organization First Street Foundation determined that millions more homes and businesses are at substantial risk of flooding than previously thought. And history backs this analysis: 75% of homes damaged by floods during Hurricane Harvey were not in Special Flood Hazard Areas (SFHAs). Changing weather patterns and continuing development will only increase flood exposures.

At the same time, new technologies are enabling the insurance industry to identify and assess flood risk as never before. Our *2020 State of Flood Report* examines innovations in flood risk management and insurance, including government-sponsored and private coverage. We aspire to raise awareness, increase understanding of current risks and the marketplace, and collectively lead innovative, sustainable solutions for mitigating and managing flood risk and speeding up the claims process during and following flood events.

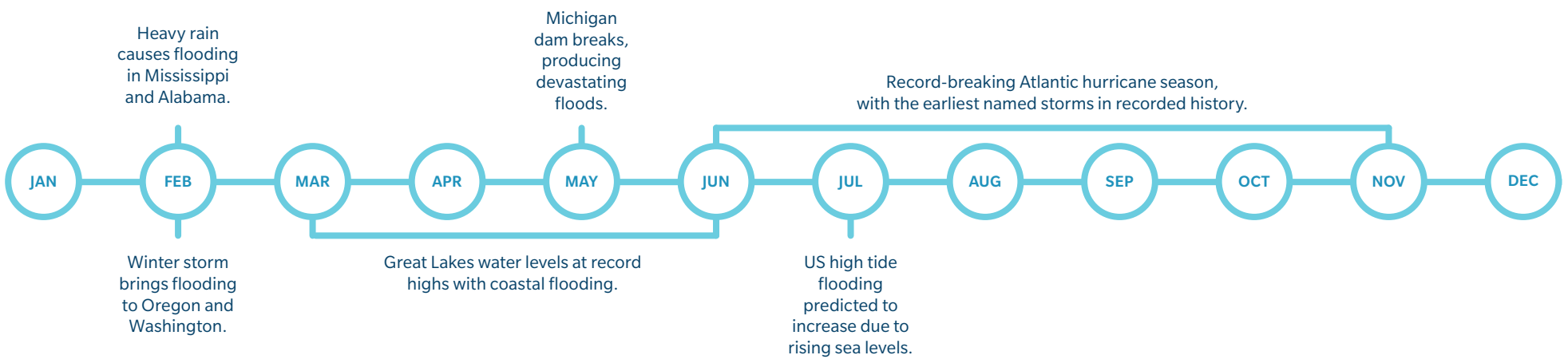
In 2020, flood risk may be overshadowed by the coronavirus pandemic and therefore not given the attention this pervasive risk deserves. But action is needed now. This report offers steps we can start taking to drive flood risk management into the future for a more protected and resilient planet, while we close the flood insurance gap here in the US.

Thank you to all who contributed to this report. We especially want to thank contributor Dr. Beverley Adams and the Marsh Catastrophic Resilience Team, who are at the helm of the Flood Resilience Center of Excellence

Kevin Tobin
President and CEO, Torrent Technologies

Flooding in 2020

SOURCE: FLOODLIST, NOAA



Executive Summary

Flood protection is typically excluded from most homeowners and small commercial insurance policies, thus requiring a separate flood insurance policy.

Various sources of flood insurance exist worldwide. Many countries, including the US, have a government-backed flood insurance program; however, not every country does. Historically, the number of private insurers offering flood protection has been limited, but the small private market is growing. This is due, in part, to recent improvements in modeling and risk analytics that have enabled insurers to better understand flood risks and loss profiles, making many more interested in offering coverage. Private insurers face three main hurdles in providing flood insurance:

An Unfamiliar Peril

The National Flood Insurance Program (NFIP) has served as the primary source of flood insurance for more than 50 years. While FEMA recently made available some loss history information — with privacy limitations — this data only covers areas currently mapped and participating in the NFIP. The Association of State Flood Plain Managers 2020 report revealed there are an estimated 2.3 million river and stream miles and just over 50,000 coastal miles that are not mapped as part of a Special Flood Hazard Area (SFHA). Industry participants, such as First Street Foundation, are taking steps to better model and understand the risk. Internationally, where flood maps exist, they are often outdated.

Profitability Concerns

In any line of insurance, accurate historical data is needed for insurers to write coverage profitably. As more historical flood data becomes available, private insurers may increase their appetite for writing flood risk.

Regulatory Barriers

Some countries with government-backed flood insurance programs, including Belgium, France, Romania, and Spain, do not permit risk-based premiums, hindering the development of a private market for flood insurance. In the US, restrictions on private insurance products that compete directly with the NFIP were lifted in 2019. State regulators must continue to create clear pathways that encourage stable private market participation.

The emergence of innovative technologies is helping expand insurers' ability to prepare for and respond to flood events, and to adapt resilience activities. Among these technologies are:

Visual Intelligence

Sophisticated satellite, aerial, and drone systems together make up a "visual intelligence" technology stack that enables observation and precise measurement of flood areas before, during, and after an event. With the further application of fluid mechanics methods, risk modeling, and loss response capabilities are quickly advancing.

Data and Analytics

The development of data, technology, and analytical tools, such as predictive flood models and water flow dynamics, enables businesses and individuals to make faster, better-informed decisions. Insurers and reinsurers rely heavily on these tools to assess the risks they assume.

Artificial Intelligence (AI)

As data and analytical tools advance, the insurance industry is turning to AI to enhance their ability to assess and underwrite risk by more accurately modeling individual risks. In the context of flood insurance, AI may provide a clearer view of exposure at specific property locations rather than wider areas, such as ZIP codes.

As technologies continue to drive a better understanding of flood risk, we may see the development of a robust worldwide private flood insurance market, along with public-private partnership solutions. Combining the strengths of a government-backed program with private sector risk analytics can lead to better solutions that better protect individuals, businesses, and communities and relieve some of the costs of disasters borne by taxpayers.

Flood Market Overview

While a government-backed program is the predominant model worldwide, not every country has a formal flood program. In addition to government-provided coverage in the US, there is a small but growing private market for flood insurance.

More than a dozen countries have established flood insurance programs in the past 50 years, either with government funding or by allowing private insurers to offer coverage. Still, in many countries, standalone flood insurance from public or private sources for individuals and businesses remains limited.

THE NFIP in the US

Created in 1968, the NFIP is the country's main source of flood insurance. In its more than five decades, the program has collected a large amount of risk data and been the subject of numerous academic analyses. FEMA administers the NFIP, which relies on Congress for periodic reauthorization. If the NFIP lapses, the program can still service existing policies, but it will be prohibited from issuing new coverage, which can constrain real estate transactions and economic development. In 2019, Congress passed five short-term extensions to avoid a lapse where the NFIP is no longer authorized to provide new flood insurance policies or renew expiring ones. In December 2019, President Donald Trump signed legislation that extends the NFIP's authorization until September 30, 2020. Congress must now pass another extension to avoid lapses in the NFIP. An extension is not assured, and the process is further complicated by 2020 being an election year and one where legislators' attention is focused on combating the COVID-19 pandemic.

STEP 1
FOR US FLOOD RESILIENCE

Extend the NFIP.

Central to NFIP insurance operations are flood insurance rate maps (FIRMs) that FEMA maintains and updates over time. The maps show various flood zones around the country, including both SFHAs and non-SFHAs. The NFIP issues policies in all communities participating in the NFIP, no matter the property's zone. Although properties in SFHAs are considered to be at a greater risk of flooding according to the mapping, any location may still flood, with researchers at the Wharton School at the University of Pennsylvania finding that more than 30% of flood losses nationwide occur outside of SFHAs. Still, many people underestimate their exposure to flood events, believing floods only happen in low-lying coastal areas or along rivers. But flooding can arise from multiple sources, including urbanization, winter storms, mud flows, and ice jams, among many other events.

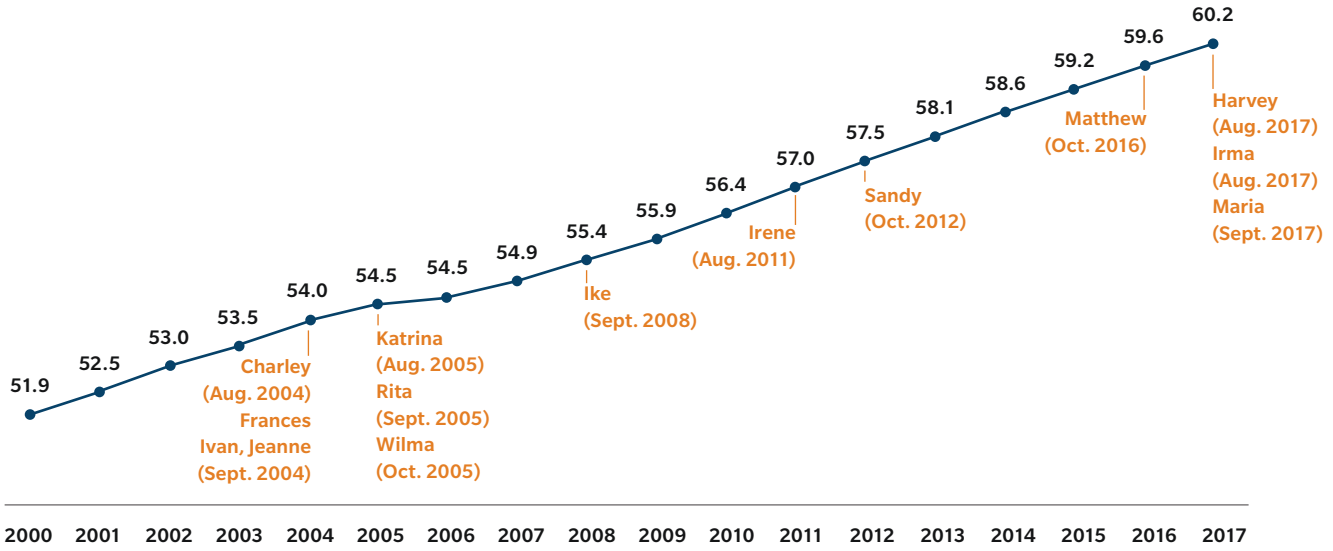
Since 1973, homeowners with a federally backed mortgage have been required to buy flood insurance if their property lies within a SFHA. Researchers at the University of Pennsylvania determined, however, that up to 50% of borrowers who should have flood insurance in SFHAs do not. Although lenders cannot close a loan until the flood insurance requirement is satisfied, some borrowers allow their flood policies to lapse. In such cases, a lender may procure insurance on the borrower's behalf, according to the loan contract.

Outside of SFHAs, few property owners buy flood insurance. This is evident when comparing NFIP policy data with the total value at risk. As of May 2020, the NFIP had slightly more than 5 million flood policies in force, with a value of $1.33 trillion, a fraction of the total value of properties with flood exposure. According to catastrophe modeling company AIR Worldwide, the estimated insured value of exposure in coastal areas in 18 states in 2018 stood at around $13.5 trillion. Over the past several decades, the population in coastal communities has skyrocketed, with data from the National Oceanic and Atmospheric Administration (NOAA) showing that approximately 40% of the US population lives in coastline counties.

Atlantic and Gulf of Mexico Coastline County Population: 2000-2017 (in millions)

Names and dates of hurricanes that caused $10 billion or more in losses

SOURCE: NATIONAL CLIMATIC DATA CENTER, US CENSUS BUREAU (2016 POPULATION ESTIMATES AND 2000-2010 INTERCENSAL ESTIMATES)



STEP 2
FOR US FLOOD RESILIENCE

Long-term reauthorization and reform of the NFIP.

Although a significant portion of the US population resides in areas with coastal flood exposure, the penetration rate of flood insurance remains low. According to a survey by the Insurance Information Institute, only 15% of American homeowners had flood insurance in 2018, up slightly from 12% in 2016.

This means that millions of people are at risk without flood protection. With the prediction of rising sea levels and increasing storms, prompt action must be taken to mitigate and solve the flood insurance gap.

Another factor that requires attention is the NFIP's $20.5 billion in debt as a result of significant flood events, including Katrina, Sandy, and Harvey.

Reform is needed to create a sound financial framework. The program must continue to update its rating methodology to follow modern actuarial practices, while Congress must consider reforms to improve the NFIP's financial well-being and encourage private market growth. This will not only help protect taxpayer dollars, but also further level the playing field with private market insurers — an important step in creating a sustainable flood insurance market for the long term.

IN FOCUS

Socioeconomic and Affordability Concerns

Social and economic challenges place a heavy burden on low-income individuals and racially diverse communities that are unable to pay for flood insurance. Where flood insurance premiums are risk-based, properties with greater exposures pay more for coverage. Flood exposure, however, does not neatly correlate with income or the ability to pay higher insurance costs. In many areas, low-income residents have a disproportionately high flood risk, making affordability of flood insurance a concern for insurers and communities around the world.

Mitigation programs, such as voluntary buyouts of flood-prone homes to return developed land to open space — also known as managed retreat — potentially favor wealthier communities, according to a 2019 research study. Managed retreat under FEMA grant programs is a complex undertaking; researchers found the time period from application to completion averages more than five years. Socioeconomic concerns make this a challenge for many communities.

Potential Solutions

More mitigation investments combined with prioritization of buyouts for lower-income communities can be a valuable tool to protect individuals and families that cannot afford to relocate on their own. Over the long term, however, these mitigation efforts could contribute to gentrification and the displacement of diverse communities, which should also be considered.

In the United States, the Homeowner Flood Insurance Affordability Act (HFIAA) of 2014 mandated that FEMA develop a framework for affordable flood insurance through the NFIP. In April 2018, FEMA issued its report, which outlined four different options:

- Income-based premium sharing. In this program, lower-income households would pay a portion of the premium and FEMA would cover the rest. As income levels rise, FEMA's contribution would decrease.
- Premium burden-based benefit. Lower-income households would pay a portion of their income for flood insurance. If coverage costs exceeded that portion, FEMA would pay for the remainder.
- House burden-based benefit. Lower-income households that spent more than a specified amount of their income on housing-related expenses, such as mortgage, taxes and insurance, would receive assistance.
- Mitigation grants or loans. The government would provide financial assistance to pay for structure-specific mitigation activities that reduce flood risk. Assistance would take the form of grants for lower-income households and loans for moderate-income households.

For all four options, FEMA proposes clearly communicating to all policyholders their full-risk premium. FEMA notes that "price is one of the best signals of risk that a consumer receives; any affordability assistance should be delivered with communication of the policyholder's full-risk, non-discounted rate." To sum it up, assistance ought to be focused on those in need while being transparent about the full risk rating of a property.

STEP 3
FOR US FLOOD RESILIENCE

Address socioeconomic issues of flooding in the US.

Since 2006, FEMA has prioritized hazard mitigation for "severe repetitive loss" properties, defined as ones that incur four or more flood insurance claim payments exceeding $5,000 each, with two occurring in a 10-year period; or having two or more flood insurance claim payments that together exceed the property's value. Severe repetitive loss properties are generally targeted for voluntary buyouts. According to the Natural Resources Defense Council (NRDC), these properties represent just 0.6% of the 5.1 million properties insured by NFIP, and account for a disproportionate 9.6% of all damages paid between 1978 and 2015, totaling $5.5 billion.

Distribution of NFIP Policies

Federal flood policies are only available through licensed agents or insurers that participate in the NFIP. The NFIP's policy distribution and administration system is comprised of:

- The Write Your Own (WYO) program, a group of approximately 58 insurance companies and their licensed agents or producers, which are authorized to issue and service NFIP-backed flood policies. As of December 2019, this number included insurers writing lender-placed flood policies in FEMA's Mortgage Portfolio Protection Program.
- NFIP Direct, which allows insurance agents not affiliated with a WYO insurer to write flood insurance directly through the NFIP.

Private Flood Insurance

Historically, the number of private insurers offering flood protection to individuals and small businesses has been limited, due to several factors, including frequency and severity of flood occurrences and the subsidization of NFIP premiums. The Homeowner Flood Insurance Affordability Act of 2014 confirmed FEMA's ability to place certain properties in lower-risk classifications if they had purchased flood insurance before new FEMA flood maps went into effect. Flood premium subsidization tend to make private flood insurance uncompetitive since some properties may remain at a lower risk irrespective of the real extent of risk. Indeed, the NFIP was created in response to the lack of a nationwide US market for flood insurance. Recent improvements in modeling and risk analytics have enabled private insurers to better understand flood risk, which in turn increases their interest in offering flood insurance.

Coverage available through private flood policies may be broader than those available under the NFIP, which are limited to $250,000 in coverage for residential structures and $100,000 for their contents. Types of current, standalone private flood insurance include:

Primary Flood

This type of insurance may replicate NFIP coverage or provide enhanced business interruption coverage for individuals and businesses through businesses, including additional living expenses. Lender-placed flood insurance is another form of primary flood coverage, typically procured by a mortgage lender to protect a property if the borrower allows required flood coverage to lapse. Also included in the primary flood category are group flood policies, which are made available by FEMA as part of disaster assistance grants and provide a lesser amount of coverage than individual flood policies. Insurers are also exploring endorsements as means of extending flood insurance to traditional homeowners policies and small commercial policies, underlining the great potential of a primary flood market.

Commercial "All-Risk"

This broad form of coverage for large businesses can provide protection for different kinds of property risks, including flood and business interruption. This type of coverage generally is not suitable for small business owners and not applicable to homeowners.

Excess Flood

Excess flood policies, which sit atop underlying private primary coverage or NFIP policies, are available for individuals and businesses. These policies can provide higher limits of coverage and cover extra living expenses and business interruption. They are available to homeowners and small business owners.

STEP 4
FOR US FLOOD RESILIENCE

Easy and simplified flood insurance options.

Spreading Flood Risk

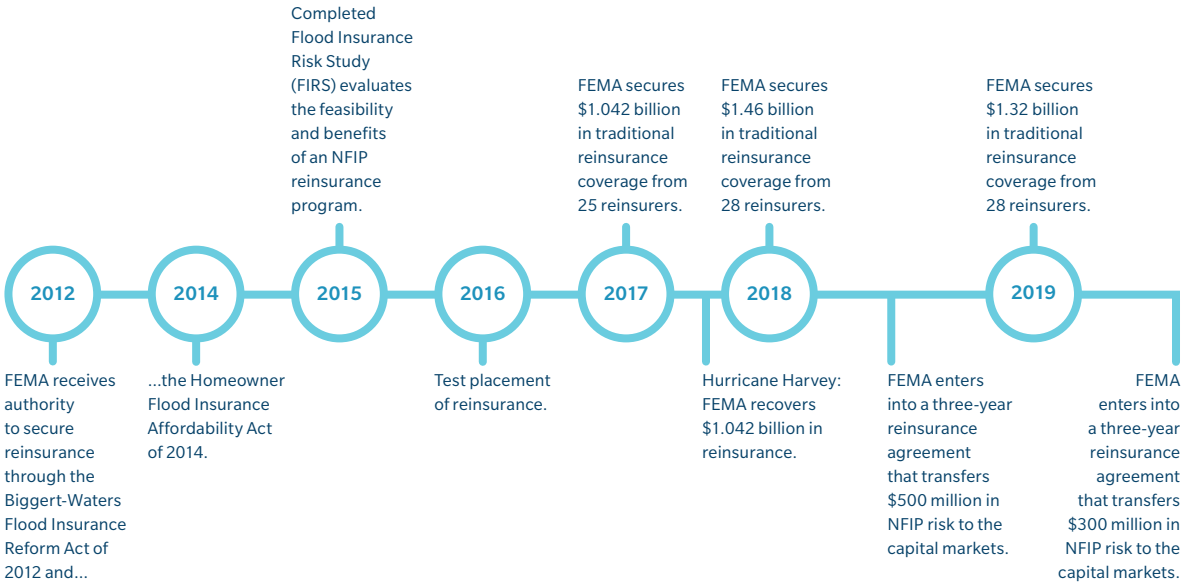
The global reinsurance market is a critical enabler of insurance. Reinsurance offers insurance entities and (re)insurance companies a means of obtaining risk capital to support their financial and risk management strategies. Reinsurance — both through commercial reinsurance companies and capital market investors that support insurance-linked securities, such as catastrophe bonds — is widely used globally to spread and manage catastrophic risk.

After the devastating flooding from Hurricane Katrina, which produced an unsustainable debt burden to the NFIP, Congress instructed FEMA to explore reinsurance as part of the NFIP's reauthorization in 2012. Previously, the NFIP did not access capital from the private sector to support its mission, instead relying on premiums and, in the event of catastrophic flooding, on the US Treasury to pay claims. On January 1, 2017, FEMA secured $1.04 billion in reinsurance and collected all of it after Hurricane Harvey. For 2020, FEMA transferred $2.53 billion to the private sector. The NFIP reinsurance program is valuable in familiarizing reinsurers and capital markets investors with the flood peril.

Reinsurance is broadly available to private and public sectors because advancements in risk funding have supported the appetite for expanded catastrophe risk capacity, both in the form of insurance and catastrophe bonds.

History of NFIP Reinsurance Program (2012 to 2019)

SOURCE: FEDERAL EMERGENCY MANAGEMENT AGENCY

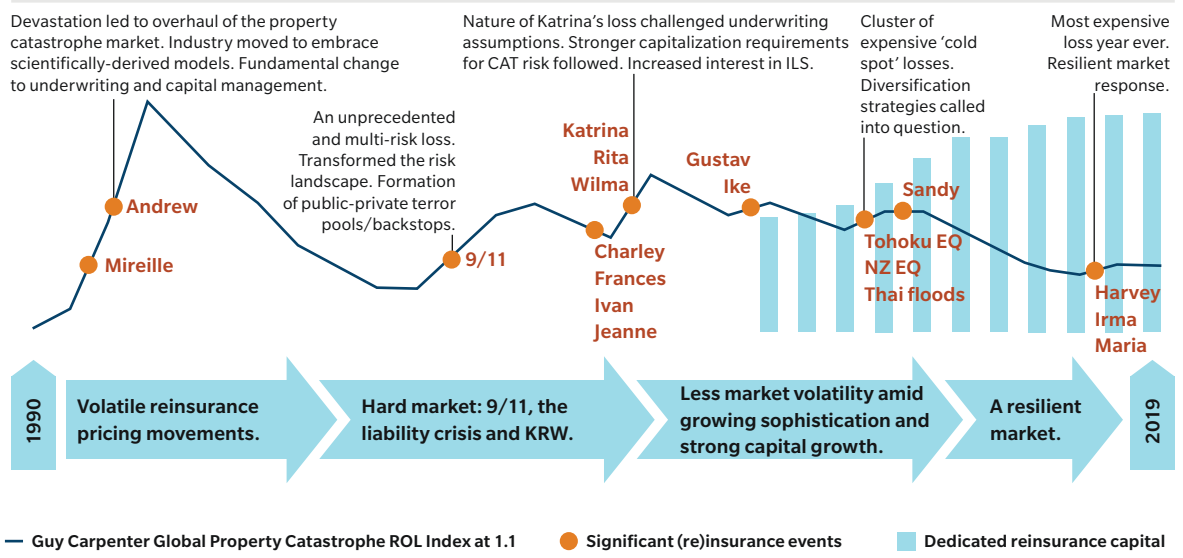


As previously mentioned, the landscape surrounding data, risk modeling, and flood mapping is swiftly changing. In areas around the world where commercial flood modeling isn't available, reinsurance companies and intermediaries, in many instances, have built models to support their clients' desire to improve underwriting and risk management capabilities.

Over the past 10 years, using commercial risk modeling to support their understanding of catastrophic risk — primarily hurricane and earthquake risk — capital market investors have become a significant capital source for the property catastrophe risk transfer market. For the US, flood risk transfer provides availability of capital for post-disaster recovery.

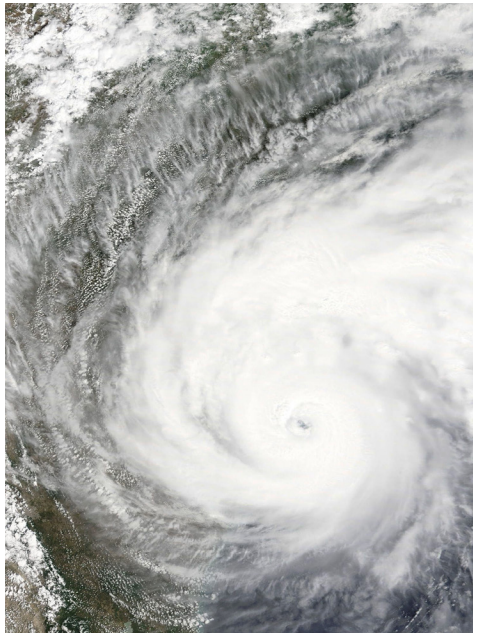
Timeline of Major (Re)insured Losses and Market Responses 1990 to 2019

SOURCE: GUY CARPENTER



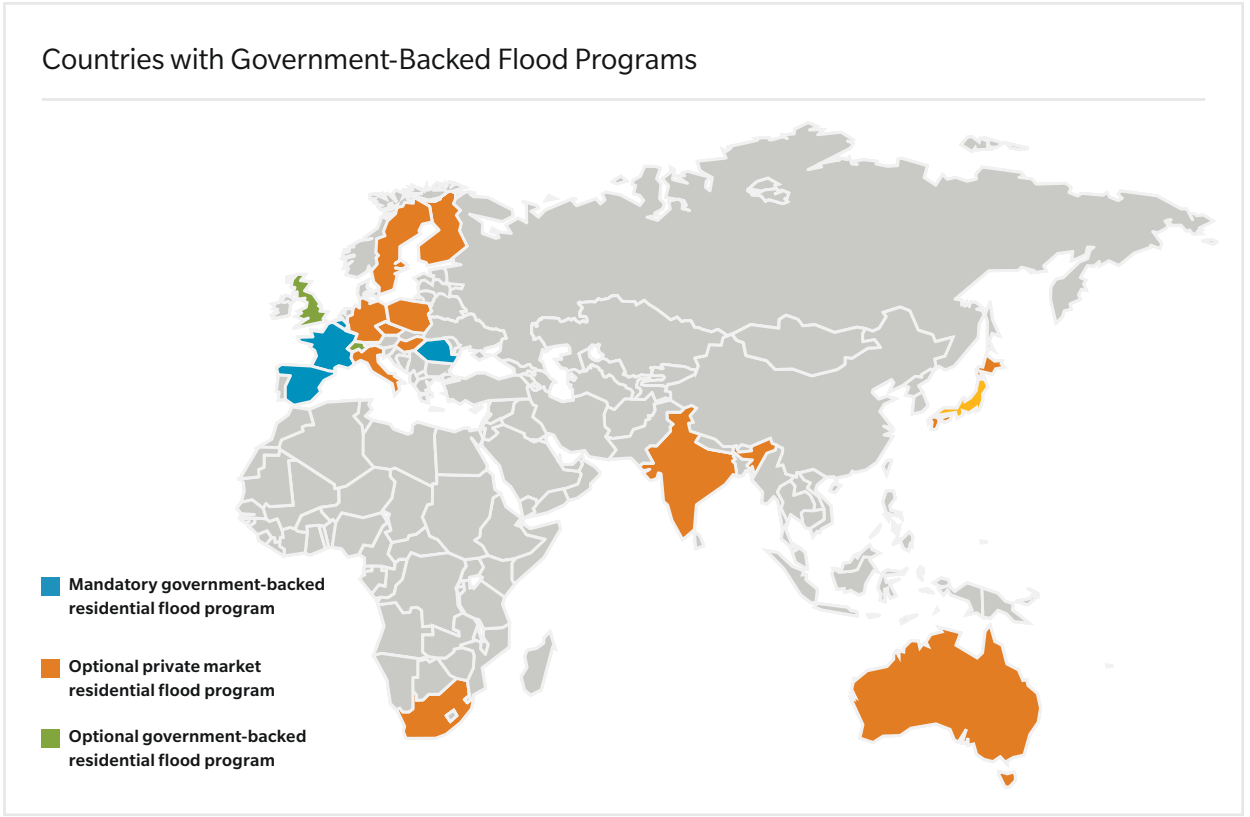
Reinsurance and 2017 Harvey

$1.04 billion recovered in seven days.



Government-Backed Flood Programs

Since the founding of the NFIP 50 years ago, several other nations have established their own flood insurance programs:



Some national flood insurance programs have special features. For example:

- In the UK, Flood Re is a government-provided reinsurance scheme for the flood component of homeowners insurance. Premiums are scaled based on flood risk and property tax bands. The program was designed to smooth the nation's transition to a private flood insurance market. Flood Re will sunset in 2039, with review every five years until then.
- Canada has a private market residential flood program, but it only applies to overland flooding. Coastal flooding in Canada's maritime provinces is generally excluded.
- China, where some of the world's most frequent floods occur, has a government-backed program that subsidizes losses of crops and livestock but not homes.
- Japan has a private market residential flood program for typhoon-related flooding only. Purchase of this coverage is optional.

A notable alternative to a national flood insurance program is in the Netherlands. Instead of promoting flood insurance through either a government-backed program or the private market, the Netherlands has chosen to implement flood defenses.

Challenges for Private Insurers

When it comes to writing flood risks around the world, private insurers face a significant challenge in gaining adequate participation by consumers. Adverse selection, in which a disproportionate percentage of policies are purchased by insureds with the highest risks, is an especially acute problem in flood, due to the potential for large, concentrated losses.

Mandating the purchase of flood insurance, as several European countries already do, can result in high coverage penetration rates. Making coverage optional, either as a standalone policy or bundled with other property insurance, tends to result in lower penetration. For example, in Belgium and France, the number of homeowners with flood insurance is high due to the compulsory nature of the coverage. Meanwhile, relatively few purchase flood coverage under Germany's and Italy's optional systems. In the US, flood insurance is mandated for federally backed home loans if the property is in an SFHA. Among other challenges for private insurers are:

An Unfamiliar Peril

As mentioned previously, data is not available for large areas within the US. Inadequate data can mean that flood maps, where they exist, are often outdated. FEMA makes historical flood claims data available through its NFIP claims data set, but similar kinds of information are not available for every geography – even within the continental US.

Profitability Concerns

The big question for every insurer is whether it can make a profit on the risks it underwrites. Flood has been a major question mark, in large part due to the lower take-up of flood coverage and lack of data that would allow for a more accurate estimation of future losses.

Regulatory and Pricing Barriers

Some countries with monopolistic government-backed flood insurance programs — including Belgium, France, Romania, and Spain — do not permit risk-based premiums, hindering the development of a competitive private market for flood insurance. In its 2019 NFIP legislation, the US Congress removed a longstanding barrier that prevented WYO insurers from offering competing insurance products. Further, countries that subsidize individuals' premiums for government-backed insurance create a competitive barrier to private insurers. The ability to offer choices and supplement existing coverage can contribute to a more vibrant private market for flood insurance.

Recurring Events

Flooding frequency is an issue for low-lying areas, which may experience recurring floods not only due to extreme weather but also during normal high tides. Resilience to flood is a function of financial protection as well as construction design to prevent or mitigate damage from water intrusion.

IN FOCUS

Environmental Events Are Pervasive Global Risks

Extreme weather, climate action failure, natural disasters, biodiversity loss, and human-made environmental disasters are the top five global risks in terms likelihood, according to the *Global Risks Report 2020*, prepared by the World Economic Forum with the support of Marsh & McLennan. Environmental-related events are also among the 10 global risks with the greatest impact. These risks speak to the influence of climate change and a need to improve resilience worldwide.

Top 5 Global Risks in Terms of Likelihood

SOURCE: WORLD ECONOMIC FORUM 2017 TO 2020, GLOBAL RISKS REPORTS, 2017 TO 2020

2017	2018	2019	2020
Extreme weather	Extreme weather	Extreme weather	Extreme weather
Involuntary migration	Natural disasters	Climate action failure	Climate action failure
Natural disasters	Cyber-attacks	Natural disasters	Natural disasters
Terrorist attacks	Data fraud or theft	Data fraud or theft	Biodiversity loss
Data fraud or theft	Climate action failure	Cyber-attacks	Human-made environmental disasters

Climate Change and Resilience

The United Nations, among other organizations, is promoting resilience and reducing vulnerability to the impacts of climate change. In June 2020, the UN Framework Convention on Climate Change (UNFCCC) held virtual meetings for participants to exchange information and continue their momentum on climate action.

In February 2020, the UK Department for Environment, Food and Rural Affairs (DEFRA) and the Property Flood Resilience Roundtable launched the UK Flood Resilience Code of Practice. The underlying principle of the code is that flood resilience must combine resistance measures with recoverability. The code is the first systematic collaboration between government, the insurance industry, and property risk managers to address flood risk specifically.

A Marsh Advisory Consulting Solutions report on flood exposure mitigation in the UK recommends 10 techniques to increase resilience:

1. **Incorporate resilience into your design.** New buildings in flood-prone areas should include floodwater resistance and recoverability measures as part of their designs.
2. **Refit and repair wisely.** Include resilience measures as part of ongoing repair and maintenance.
3. **Build back resilient.** Insist on post-event restoration that provides for resilience elements.
4. **Level the playing field with insurers.** Model flood risk to ensure that underwriters are giving proper credit for flood defenses.
5. **Invest resiliently.** Support due diligence for investments by including a flood assessment.
6. **Comply with insurance coverage standards.** When traditional flood coverage is less available or requires retaining more risk, consider innovations such as parametric insurance.
7. **Know and mitigate high-risk locations.** Understand where the organization's "hot spots" are for flooding.
8. **Develop a corporate flood resilience strategy.** Consider all aspects of the potential impact of flooding, including business interruption, injuries to people, and reputational damage.
9. **Build flood emergency response plans.** Make site-level flood plans part of local crisis management programs and familiarize all stakeholders with them.
10. **Consider instant insurance.** Parametric insurance in tandem with resilience measures can provide quick payouts when floodwaters rise.

In the US, building code requirements differ in SFHAs and vary by flood zone as well as type of facility. For example, both the NFIP and the International Code Series of construction codes require the lowest floor to be at or above the base flood elevation (BFE). Below BFE, residential structures must use flood damage-resistant materials such as breakaway walls and openings to allow entry and exit of floodwaters. In addition, utilities must be situated at or above the lowest required floor elevation.

The Disaster Recovery Reform Act of 2018 led to FEMA's Building Resilient Infrastructure and Communities (BRIC) program, which reinforces community mitigation efforts to reduce risk. BRIC is funded by a 6% set-aside from federal post-disaster grant funding and in 2020 will begin accepting grant applications. These are steps in the right direction that incorporate building codes, community lifelines, nature-based solutions and more to create a more resilient US.

Insurers can provide financial protection to rebuild, but it will take government involvement to pay for the long-term costs of climate change. The effects of rising sea levels will require serious consideration by governments and communities and coordinated efforts to strengthen flood defenses.

STEP 5
FOR US FLOOD RESILIENCE

Continuous reinforcement of resilience efforts to proactively address climate change.

An option is community-based catastrophe insurance (CBCI) when a community arranges insurance protection for its members. CBCI options are vast and could be either voluntary or mandatory. One model may allow a community to help arrange coverage for its members with one insurer or multiple insurers. Another model would have the community set up its own captive insurance company.

What will the future look like for flood insurance? As insurers embrace technologies that enable them to better understand and evaluate flood risk, new products are developed to address differing needs of consumers and businesses, and buyers come to recognize their true exposure to flood risk, a strong private market may emerge.

Flood **resilience** is a combination of:

1. Resistance
Measures that hold back water.

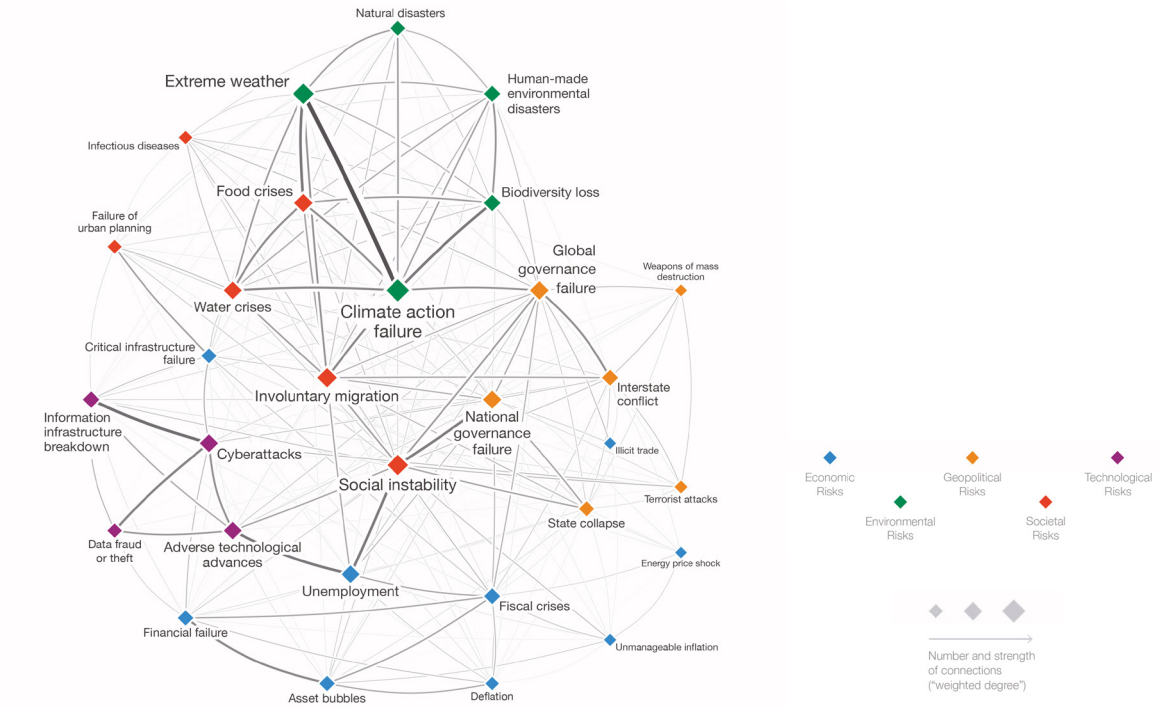
2. Recoverability
Measures that minimize the impact and speed of recovery should water enter a facility.

RESISTANCE + RECOVERABILITY = RESILIENCE

Climate is positioned top-center of the global risk interconnections map, showcasing the critical nature of this threat.

Global Risks Interconnections Map 2020

SOURCE: THE GLOBAL RISKS REPORT 2020



Innovations in Flood Risk Management

The emergence of innovative technologies is helping expand the insurance industry's ability to prepare for and respond to flood events and is informing resilience activities. Among these emerging technologies are:

Visual Intelligence

The use of sophisticated satellite, aerial, and drone systems together enable observation and the precise measurement of areas prone to flooding. A variety of camera systems — including optical, thermal, radar, and other sensors — are deployed to capture different features of the flood environment before and after loss events. These technologies increase knowledge of the dynamics of elevation, topography, and extent of floodwater, and provide a safe way to gather data on the extent and depth of flooding. Together with fluid dynamic principles, visual intelligence insights are useful in analyzing and pricing flood risk and guiding resilient repairs.

A visual intelligence concept of operations for flood response combines visual intelligence with data, analytics, monitoring, and planning to enhance flood response by communities and the insurance industry (see page 20).

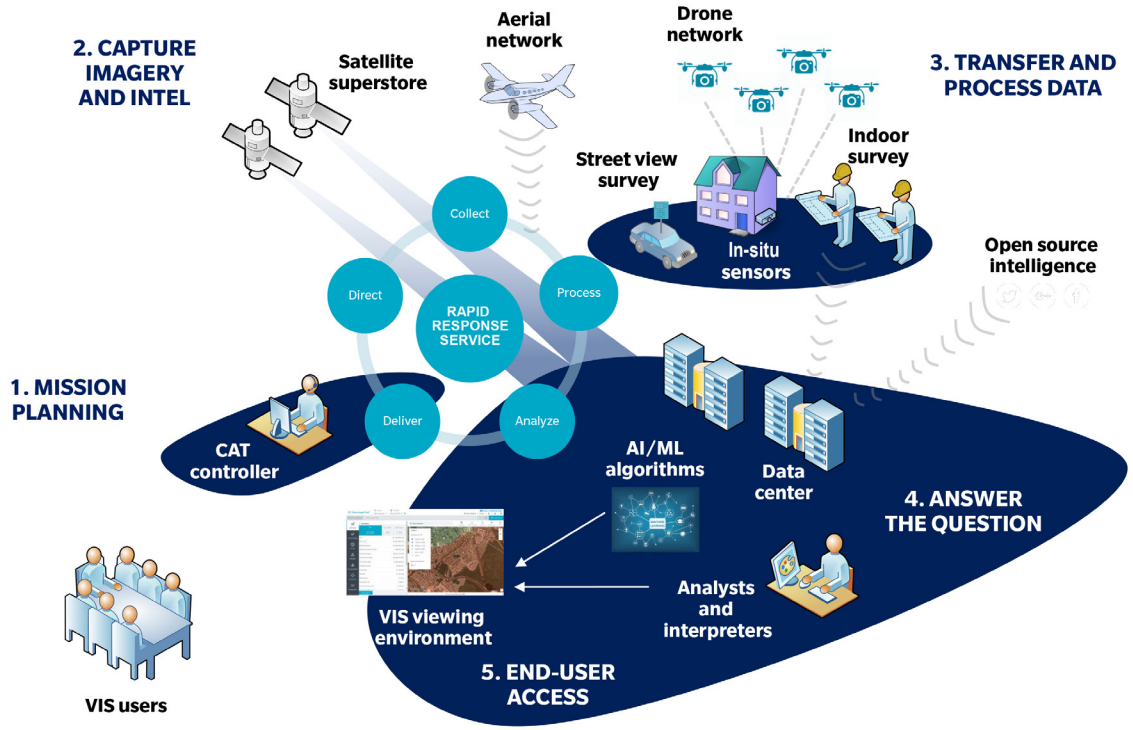
This concept of operations — developed by Dr. Beverley Adams, head of visual intelligence and catastrophe planning at Marsh Advisory Consulting Solutions and a member of a team of experts advising Flood Re, the UK's national flood insurance program — includes a number of steps:

- **Control and access.** Users of the visual intelligence system are identified and given access.
- **Monitor, trigger, and mission plan.** An appointed catastrophe controller is responsible for monitoring events. Based on agreed parameters, flood events trigger a rapid response to gather more data.
- **Capture visual intelligence.** Various tools — from satellites to planes, drones, and field surveys — are used to collect visual data on flood events.
- **Transfer and process data.** The data is uploaded into the visual intelligence system.
- **Analytics consulting.** Visual data is examined and analyzed.
- **Visualization reporting and sharing.** Findings are reported and shared with the system's users.

Visual technology	Typical altitude	Pre-loss	Post-loss	Notes
Drones	Up to 400 feet in daylight	✓	✓	Enables detailed inspection of property-specific damage
IFSAR and DTM	Up to 30,000 feet	✓	✓	Clearly shows bare earth features
Aerial imagery	Up to 40,000 feet	✓	✓	Captures wide-area images
LIDAR	Up to 140 miles or higher	✓	✓	Deployable by multiple means
Satellites (low earth orbit)	62 to 1,200 miles	✓		Facilitate earth observation
Satellites (geostationary)	22,000+ miles	✓		Aid storm tracking

The insurance industry can apply an impressive array of visual intelligence tools to manage flood risks. All aerial technologies can contribute to pre-loss data collection and analysis, though several also provide valuable post-loss information.

Flood Response Concept of Operation



STEP 6
FOR US FLOOD RESILIENCE

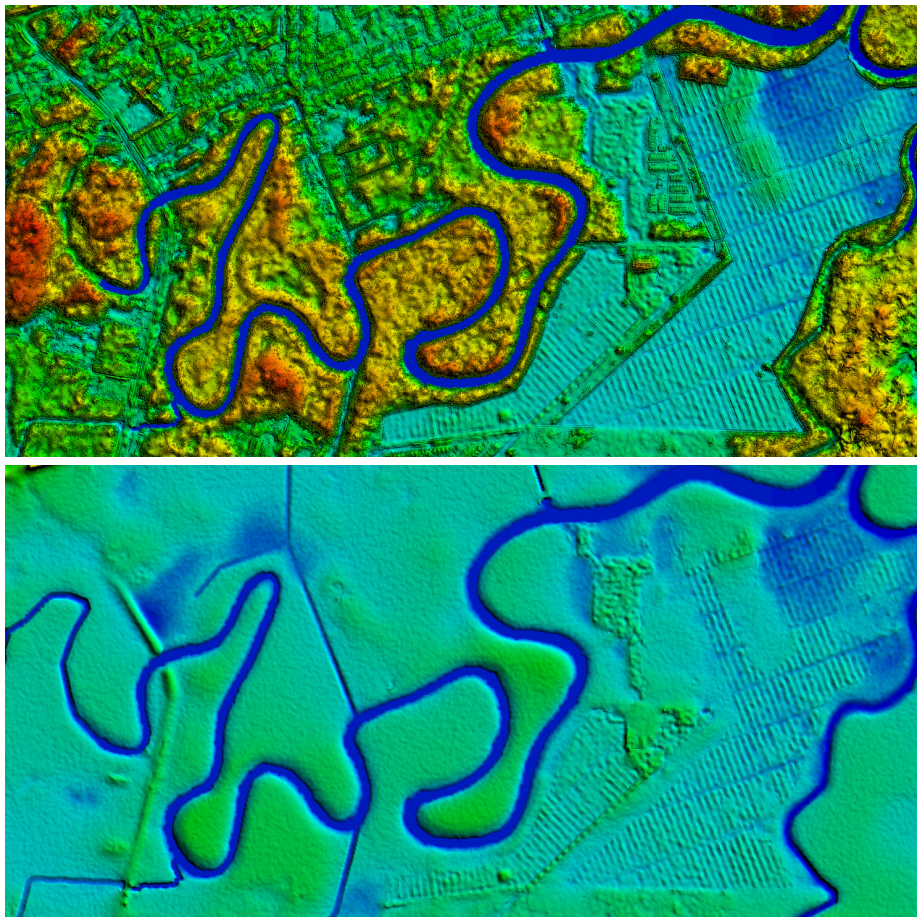
Use technology for property-level flood risk scoring and claims handling.

Among technologies especially helpful to underwriters in assessing the potential for inundation at a given property are:

Light Detection and Ranging (LIDAR)

Scientists and cartographers use this remote sensing method to measure and create digital elevation models of Earth's surface. Types of LIDAR include topographic, which senses changes in land, and bathymetric, which measures elevation changes in riverbeds, lakes, and the seafloor.

Experiments conducted by the National Aeronautics and Space Administration (NASA) have shown LIDAR to be effective, at varying accuracies, during high-altitude flights and even from space. LIDAR uses laser pulses emitted from equipment on board airplanes and helicopters to capture precise, three-dimensional data. The science behind LIDAR has existed for more than 50 years, but improvements in laser technology



Top: An aerial digital surface model showing a river in Luzon, Philippines, with structures and vegetation visible.

Bottom: The same location, using digital terrain mapping and geospatial editing to show bare-earth elevations.

(Images courtesy of Intermap)

continue to enhance it. LIDAR's flexibility and accuracy make it particularly helpful in determining elevation and mapping areas vulnerable to flood and storm surge. In addition, LIDAR's accuracy is making elevation certificates — normally required to insure a property in or near a flood zone — unnecessary for the issuance of flood insurance. Obtaining an elevation certificate requires use of a certified land surveyor, engineer, or architect, and can take days or weeks. LIDAR, therefore, is especially valuable in building a flood risk profile, before a flood occurs.

Digital Terrain Mapping (DTM)

Elevation and proximity to sources of flood — rivers or other bodies of water — are highly correlated with flood risk. Digital surface model (DSM) data can be captured by LIDAR or interferometric synthetic aperture radar (IFSAR). An enhanced form of calculating elevation, DTM takes DSM data and uses geospatial editing to create detailed models of large tracts of bare earth by removing structures and vegetation from the image. DTM data can be gathered from satellites, but delivers greater surface detail when collected during aerial LIDAR flights (see photographs). DTM technology is well-suited to assessing flood risk because it creates a picture of where the ground is at any given point on the digital map, rather than relying on averages, as many catastrophe models do. DTM is a valuable tool in determining a flood risk score, which correlates to the return period for flood at a specific location.

Optical Satellite Imagery

Optical imagery is another important form of visual intelligence, useful for baselining the general characteristics of at-risk properties. Although not new, its improvement and expansion for civilian use have made high-resolution images of the earth widely available. Downsides to satellite imaging include the coarser resolution compared with optical aerial and drone imagery, inability to provide images in real time, and susceptibility to atmospheric conditions. For example, cloud formations are constantly changing and can obscure satellites' ability to capture details below the cloud cover. However, satellites are useful for tracking developing storms and weather patterns, and often are complemented by ground-based radar systems that track rainfall in specific areas.

As of July 8, 2020 there have been 10 weather/climate events in the US, each with losses exceeding $1B.

Visual intelligence tools that are useful before and after a flood event include:

Aerial Imagery

Offering higher resolution than a satellites and covering a wider area than drones, aerial imagery provides "blue sky" pre-loss benchmarking of property characteristics. Aerial systems are also rapidly deployed for "gray sky" coverage post-event, though deployment is subject to weather and regulations. For example, during Hurricane Harvey, persistent rain grounded aircraft. In addition, aviation authorities typically put in place temporary flight restrictions during disasters to ensure safety for all users of the airspace. Aerial systems can deploy optical, thermal, LIDAR, and IFSAR sensors.

Aerial photograph taken by a drone showing flood damage in a residential neighborhood in Houston after Hurricane Harvey.

Drones

An increasingly popular form of visual intelligence, drones — technically known as unmanned aerial vehicle systems — are becoming valuable tools for pre-loss condition and risk assessment and post-loss evaluation. Drones range widely in size and weight, vary by means of propulsion — for example, fixed-wing or rotary wing — and have differing payload capabilities. Drones are capable of deploying optical, thermal, and LIDAR cameras.

Drones equipped with cameras and sensors are especially helpful to the insurance industry when access to affected areas is dangerous or impossible, such as after a hurricane. Drones can capture 360-degree panoramic views when using straight ascents. This provides widespread coverage while avoiding regulatory issues relating to deploying beyond an operator's line of sight and risk management issues when deploying above populated areas. The Federal Aviation Administration and the UK Civil Aviation Authority restrict drone flights to the same relatively low ceiling of 400 feet, well below most cloud bands. In addition, drones are capable of delivering "live" images and video footage through real-time data uplinks.

These technologies provide both pre- and post-loss benefits. From an insurance perspective, visual intelligence enables insurers to see what a property or area looks like before and after a disaster. Visual intelligence tools allow insurers to conduct triage for claim inspections and accelerate claim payments. Using these technologies to gather visual information soon after a disaster can accelerate response and recovery. For example, instead of waiting until a claims adjuster can visually inspect a property after a windstorm, some insurers will consider aerial images that confirm flooding or roof damage as sufficient to begin issuing claim payments.

Data and Analytics

The evolution of data, technology, and analytical tools enables businesses and individuals to make faster, better-informed decisions. Insurers and reinsurers rely heavily on data and analytics to assess the risks they assume.

An area where data and analytics are proving to be especially helpful in mitigating risk is predictive flood models. For most of its history, FEMA has used a deterministic model for SFHAs, a time-consuming and expensive process that requires physical observation and measurement at distinct points and that must be updated periodically to account for physical and climatic changes. Predictive modeling, on the other hand, synthesizes data to develop a probabilistic view. FEMA now is employing probabilistic models that support its use of reinsurance, NFIP's risk rating modernization initiative, and the program's overall risk management efforts.

Predictive models are widely used for the wind fields of hurricanes, which can cover large areas. Flooding, however, is a localized phenomenon, with many variables. The development of accurate flood models, particularly for inland and urban flooding, is accelerating. Global flood models are being built and adapted for commercial applications.

Other areas of innovation include policy distribution and claims reporting, which are underpinned by data and analytics. Mobile technology that connects to relevant data sets makes it possible for agents to quote and bind flood policies in as little as three minutes.

IN FOCUS

Computing Effects of Climate Change

Sophisticated technology is enabling scientists to measure climate change, from atmospheric conditions to ocean temperatures to sea level rise. The effects of these changes include greater volatility in weather events, shifts in seasonal precipitation, and increased rates of glacial melting.

Rising sea levels are a particular concern since a majority of the world's population lives in or near coastal areas. As noted earlier, approximately 40% of the US population or 127 million people live in coastal counties, putting them at risk of storm surge and extreme tides — both significant sources of coastal flooding.

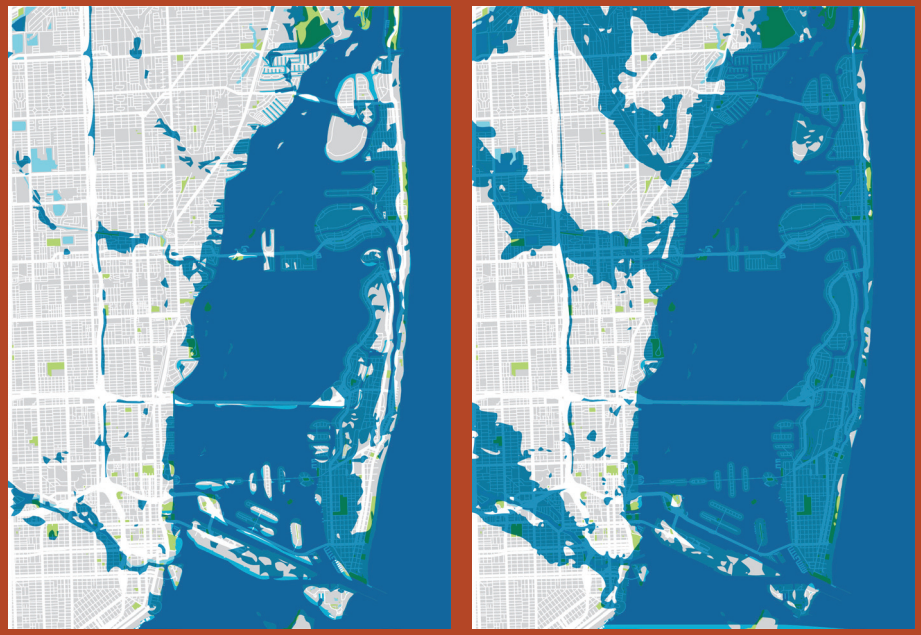
The National Oceanic and Atmospheric Administration's (NOAA) recently published State of High Tide Flooding Report reveals that "sunny day" flooding increases as a result of sea level rise. NOAA estimates that by 2030, the current high tide flooding numbers could increase two- or threefold. By 2050, it could be five- to fifteenfold more.

Estimates of the amount of sea level rise occurring by 2100 vary, but evidence reviewed by NASA indicates a median rise of 0.86 meters (2.8 feet). NOAA images using an "intermediate high" sea level rise estimate of 1.9 feet shows the impact to Miami and its surrounding area (see figures at right).

Cities around the world are threatened by rising sea levels. Like all communities in low-lying areas, Miami, at just six feet above sea level, has a serious exposure to flooding. The nearly 2.8 million people in the Miami-Dade County metropolitan area experience flooding not only from hurricanes and tropical storms, but also from higher-than-normal tides. Even without rainfall and wind-driven water, Miami's streets often flood due to high tides.

Rising Sea Levels in Miami

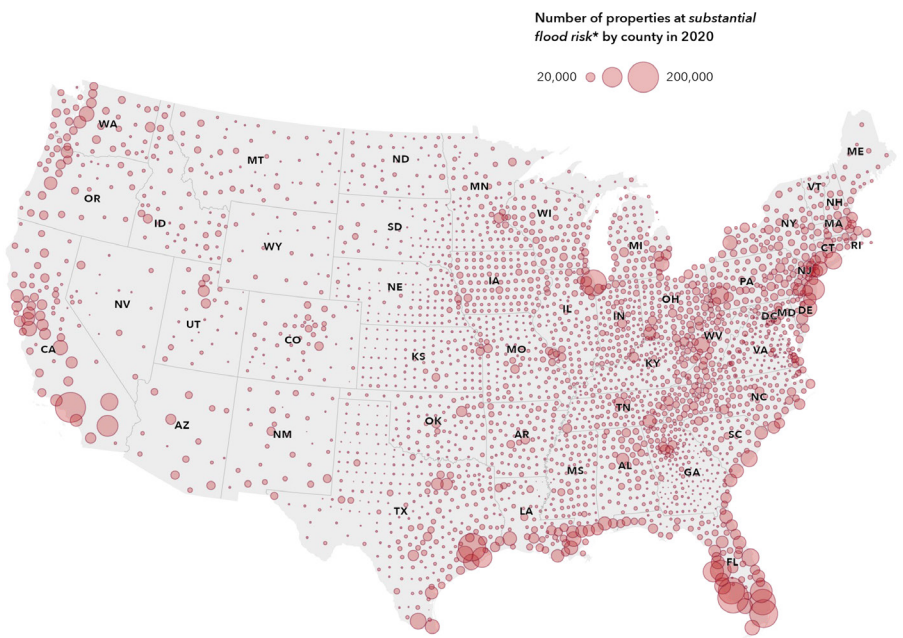
SOURCE: NOAA



2060 (in just 40 years) **2100 (in just 80 years)**

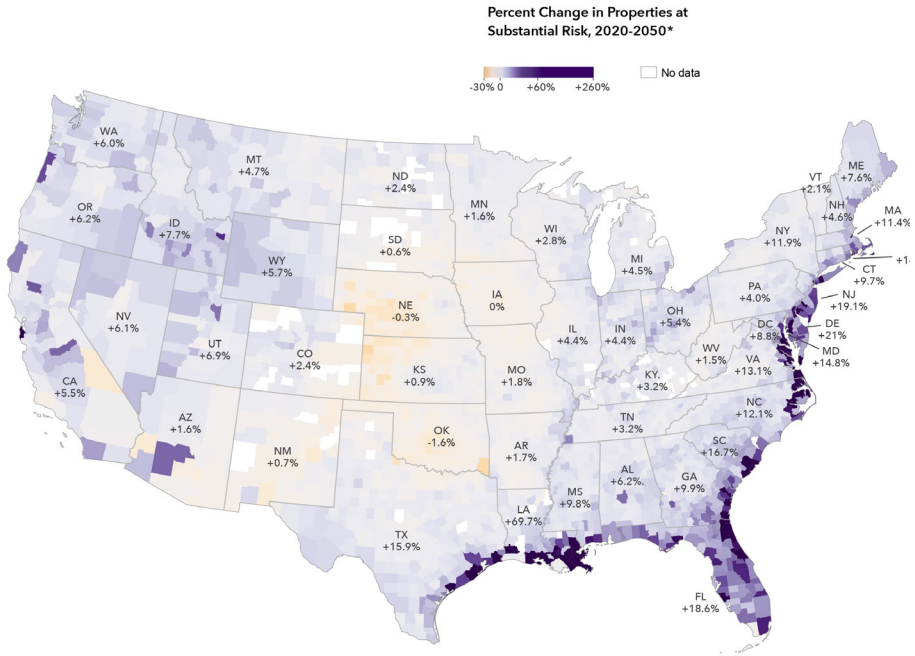
Properties with Substantial Flood Risk — National Overview

SOURCE: FIRST STREET FOUNDATION



Increasing Flood Risk Over the Next 30 Years

SOURCE: FIRST STREET FOUNDATION



*** Substantial risk is calculated as inundation 1 cm or more to the building in the 100 return period (1% annual risk). See methodology for full model details.**

Actions to Begin Taking Now

As innovative technologies continue to improve the understanding of flood risk, the potential for a robust private flood insurance market worldwide keeps growing. To promote greater access to flood insurance and to improve flood protection, we propose the following recommendations, for governments, regulatory authorities, and the insurance industry:

Simplify the Process

Make it easy for agents to sell flood insurance and for individuals and businesses to purchase flood insurance. Establishing mitigation programs that are equitable, agile, and uncomplicated allow more people to get protection.

Amplify Resilience

Build new structures with flood resilience in mind, and retrofit existing structures to be more resilient. A key principle of the UK Property Flood Resilience Code of Practice is to combine resistance — keeping floodwaters out — with speedy recoverability for flood victims.

Share Flood Risk Data

It is important for governments, emergency management agencies, and the insurance industry to learn from other countries' approaches. Two prime examples are the UK's Flood Re and the US's NFIP. Flood Re makes flood coverage available through private insurers, with assessments supporting a government-provided reinsurance program. The goal is to facilitate the transition to a fully private flood insurance market. The NFIP is currently the solution for providing government-backed coverage for properties at greatest risk.

Explore Public-Private Partnerships

Combining the strengths of a government-backed program, such as the NFIP, and private-sector risk analytics can lead to solutions that protect individuals, businesses, and communities from the impact of floods and relieve some of the costs of disasters borne by taxpayers. Encouraging private insurers' involvement in — rather than competition with — government programs can expand consumer choices and increase the purchase of flood protection.

Promote Awareness of Flood Risk and Continue Resilience Efforts

Continued education of consumers and regulators about the nature and severity of flood risk is important. As people and businesses realize their potential exposures, they may be more likely to adopt resistance and recoverability measures for greater resilience.

Continue Innovations in Flood-Related Technology at the Individual Property Level

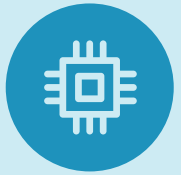
Today's technology can generate highly detailed visual depictions of flood risk to show where exposures are located. Continued innovations in modelling, flow dynamics, and flood risk mapping can promote a more coordinated national response to catastrophe events, improve community resilience, and make taxpayer funding of disaster assistance less necessary. In addition, visual intelligence technology can facilitate instant loss assessments, accelerate payment of claims, and inform post-event repair decisions to make individual properties more resilient.

Parametric Solutions

Parametric insurance policies offer a streamlined way to respond to flood and other risks. These policies, which complement traditional insurance, are triggered by predefined parameter(s), such as rainfall or windspeed, and can pay out without the need for extensive loss adjusting, allowing for swift recovery that is essential to help people in the moments that matter. Parametric insurance is becoming more common around the world in protecting various industries from catastrophe and weather-related losses. Parametric options present great opportunity for communities to address fiscal needs post-disaster.

Actions Torrent is Taking

As part of our commitment to closing the flood insurance gap in the US, Torrent is:



Enhancing Customer Experiences via Technology

Our existing online portal makes it easier for our clients to purchase flood insurance and rapidly respond to a flood event. Torrent is in the process of launching a new policyholder portal and has private flood insurance integrated within the quoting platform for more personalized, property-level protections.

Curating a Private Flood Portfolio

Strategic flood insurance designed for commercial and residential properties is part of Torrent's growing network of built-in products available in the flood insurance quoting portal.

Building Resiliency

Through our relationships and access to the Marsh Center of Excellence for flood resiliency, Torrent is paving the path for proactive engagement within the public and private sectors that is necessary for a US flood resiliency practice. Creating a platform for flood insurance that allows easy access to agents will help sustain and grow the flood insurance market. Torrent's collaboration with FEMA through the Write Your Own and NFIP Direct programs provides the opportunity to help close the flood insurance gap in the US.

The COVID-19 pandemic has reinforced the critical importance of planning and actions to prepare, recover, and mitigate to protect people and property from the devastating effects of flood. Now is the time to work together to close this flood insurance gap.

ABOUT TORRENT TECHNOLOGIES

Torrent Technologies Inc. is a business services subsidiary of Marsh that leverages technology to improve the underwriting, distribution and claims service of flood insurance. About 75% of Torrent's Write Your Own (WYO) carrier clients utilize its full business process outsourcing capabilities, which include underwriting, claims, accounting, agency support, information technology and mailing services. A cloud-based, software as a service model enables clients to retain elements of flood insurance servicing. With an agile approach to technology, Torrent has been able to accelerate quoting, policy issuance, and claim payments. Torrent also offers automated private primary flood and excess flood policies for WYOs, their agents and clients.

ABOUT MARSH

Marsh is the world's leading insurance broker and risk adviser. With over 35,000 colleagues operating in more than 130 countries, Marsh serves commercial and individual clients with data driven risk solutions and advisory services. Marsh is a wholly owned subsidiary of Marsh & McLennan Companies (NYSE: MMC), the leading global professional services firm in the areas of risk, strategy and people. With annual revenue approaching US$17 billion and 76,000 colleagues worldwide, MMC helps clients navigate an increasingly dynamic and complex environment through four market-leading firms: Marsh, Guy Carpenter, Mercer, and Oliver Wyman. Follow Marsh on Twitter @MarshGlobal; LinkedIn; Facebook; and YouTube, or subscribe to *BRINK*.

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