Climate Risk and the Shifting Insurance Landscape

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Executive Summary

As extreme weather becomes common, impacted communities are often unable to recover. Patchwork insurance coverage, legal loopholes that enable prohibitively expensive insurance rate hikes and a lack of data analytics and modeling have permanently damaged the economies of vulnerable communities. Catastrophic natural disasters such as Hurricane Helene have demonstrated that even areas once touted as 'climate havens' are vulnerable.

This analysis provides an overview of how climate risk is impacting the insurance sector with an emphasis on North Carolina. Across the state, North Carolinians face acute threats from extreme weather, including sea level rise and saltwater intrusion in the eastern part of the state, flash flooding across the Piedmont and Appalachians and extreme heat statewide. State policy has encouraged communities to build climate-resilient infrastructure, but large gaps still exist in insurance industry regulations and in providing affordable insurance to communities.

Climate change impacts all insurance sectors, with real estate and energy industries facing the most acute physical risks. Mainstream insurers are retreating from areas with elevated climate risk, with high nonrenewal rates for insurance policies seen in California, Florida and Eastern North Carolina. Private companies are gaining more prominent roles in sectors traditionally dominated by the government, such as flood insurance and weather modeling.

Institutions are responding to climate risk by rethinking their approach to asset management. Governments are seeking more resources to better insure their facilities and are facilitating a 'managed retreat' to move people and infrastructure

out of chronically flooded coastal areas. Private companies are facing pressure from regulators, shareholders and community activists to relocate infrastructure out of high-risk areas.

Insurers play a critical role in moving the needle towards climate resiliency. New insurance models such as parametric insurance, public-private risk-sharing programs and community engagement from insurers allow companies to remain in high-risk zones by materially reducing the physical risks to infrastructure. Innovations are needed for economic activity to continue in these areas, as insurance underpins nearly all modern business transactions.

Providing effective risk mitigation solutions is a golden opportunity for new ventures. Companies offering improved grid resiliency, advanced modeling and coastal defense solutions are in high demand. An exciting opportunity exists for new businesses that will enable government and business leaders to effectively prepare for the next storm.

The State of Climate and Insurance in North Carolina

The Impacts of Hurricane Helene

Hurricane Helene was a wake-up call for many in North Carolina, as the devastating storm exposed deep gaps in insurance coverage and highlighted the increased risk that insurance companies face in an era of climate change. In Western North Carolina, fewer than 2.5% of residents were enrolled in the National Flood Insurance Program (NFIP), leaving many with insufficient resources to rebuild. For the few that were covered under the NFIP, FEMA regulations stipulate that policyholders must first be rejected by a private insurance company before requesting assistance from the NFIP. However, insurance companies were penalizing policyholders for reaching out to the NFIP, which is against North Carolina state law. North Carolina's "consent to rate loophole" allows insurance companies to charge up to 250% of state rates, leaving residents few affordable private insurance options. State flood insurance programs such as the Coastal Property Insurance Pool were not geared toward the Western part of the state and did not provide relief for property owners. Though Governor Josh Stein's Hurricane Helene recovery plan suggests small changes such as requiring more school districts to purchase flood insurance, it does not recommend any systemic changes to insurance regulation.

The impacts of Hurricane Helene have led many stakeholders to incorporate resilient design into recovery efforts. Duke Energy is updating its storm preparedness protocols in the wake of Helene. This involves burying more distribution lines, replacing wooden distribution poles with stronger materials, and constructing permanent barriers around substations that are prone to flooding. The city of Asheville is using FEMA funding to rebuild its riverfront in a flood-resilient manner, restoring parkland and removing infrastructure from this flood-prone area. In May 2025, the city broke ground on a $23.3 million improvement to its water treatment infrastructure, as the city was without water for 53 days after Hurricane Helene.

However, post-Helene reform is stalling on other fronts, such as in building codes. In 2023, the North Carolina General Assembly passed HB 488, which blocks any updates to building codes until 2031. Presently, the General Assembly is also considering SB 266, which would exempt structures destroyed by Helene from adhering to current building codes. The North Carolina Department of Transportation is experiencing financial challenges post-Helene, resulting in the inexpensive and quick reconstruction of roads instead of prioritizing resilience in the rebuild. Staffing cuts in the regional offices of the National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA) have reduced capabilities to detect and track future hurricanes.

Sea level rise in Eastern North Carolina

750 (~ 9%) of oceanfront structures along the North Carolina coast are at risk of falling into the ocean. The flat nature of the North Carolina coastline makes it uniquely vulnerable to sea level rise (SLR). North Carolina's coastline is heavily influenced by federal policies, such as the Coastal Barrier Resources Act (CoBRA), which was passed by Congress in 1982. CoBRA gives the U.S. Fish and Wildlife Service (USFWS) the authority to designate certain areas as 'CoBRA zones,' flood-prone coastal areas that are ineligible to receive any federal financial assistance, most notably flood insurance. Research has shown that CoBRA has significantly reduced, but not eliminated, urban development in designated 'CoBRA zones'. By removing financial assistance for flood-prone coastal developments, it has been estimated that CoBRA has reduced federal disaster expenditures by $9.5 billion and is projected to reduce costs by up to $108 billion by 2068.

Even if CoBRA has slowed development in flood-prone coastal areas, its main downside is that it leaves many vulnerable properties without flood insurance, as private insurers are generally unwilling to issue policies in CoBRA zones. Much of the North Carolina coast is designated a CoBRA zone, especially in the Outer Banks and on Topsail Island.

In addition to flooding, coastal erosion is a major threat to properties along the North Carolina coast. The collapse of homes into the ocean in Rodanthe has garnered major media attention and is often cited as a policy failure in coastal resilience and risk mitigation. Ironically, homeowners are incentivized to pack as many valuables into their compromised homes as possible, as this increases the insurance payouts they will receive. However, an expired provision of the NFIP called the Upton-Jones Amendment would have changed the incentive structure for the Rodanthe homeowners. The Upton-Jones Amendment provided funding to demolish or relocate homes impacted by coastal erosion. This would have vastly improved the economics of relocation for many homeowners.

Despite challenges, North Carolina is still seen as a leader in coastal zone management. Since 1974, the North Carolina Department of Environmental Quality (NC DEQ) has implemented the Coastal Area Management Act (CAMA), which restricts development in flood-prone or ecologically sensitive areas of the North Carolina coast. A significant provision of CAMA is that it bans concrete embankments on oceanfront properties, as this degrades beach quality and size. However, many property owners have relied on concrete to protect their properties from erosion. This provides a market opportunity for living shorelines, which have the same erosion-control benefits and are CAMA-compliant. Living shoreline innovations, such as those pioneered by Natrx Adaptive Infrastructure and Sandbar Oyster Company, can significantly reduce flooding and erosion risk for coastal properties.

State policy

Though the North Carolina Department of Insurance (NC DOI) is the primary determinant of state insurance policy, other government agencies play a significant role in determining the accessibility and affordability of insurance in North Carolina. NC DOI regulates how much private insurance rates can be increased. For homeowners insurance, NC DOl approved a 7.5% hike in insurance rates for both 2025 and 2026. Ratemaking officials must walk a tight line between protecting

consumers and allowing insurance companies to receive enough profit so that they will remain in the state. Climate change has complicated this balance, as private insurers like Nationwide declined to renew over 10,000 homeowners insurance policies in flood-prone areas of Eastern North Carolina.

As private insurance companies begin to pull out of markets due to climate risk, more residents will turn to 'insurers of last resort,' government-backed entities that are willing to take more risk. North Carolina law has established two insurers of last resort: the North Carolina Joint Underwriting Association (NCJUA) and the North Carolina Insurance Underwriting Association (NCIUA). Both NCJUA and NCIUA only provide property insurance and do not offer flood insurance, meaning that residents must work with the NFIP if they would like flood insurance. NCJUA (also known as the FAIR plan) offers all-inclusive property insurance (including fire, lightning, wind, hail, and theft) to properties that cannot secure private insurance. However, properties located in 'beach areas' are not eligible under NCJUA. NCIUA (also known as the Coastal Property Insurance Pool) is the organization designed to serve as an insurer of last resort for coastal property owners. With a similar structure to NCJUA, NCIUA has programs tailored towards reducing hurricane damage, such as strengthening roofs.

In conjunction with NCJUA and NCIUA, the state also offers property improvement programs to mitigate damage when a natural disaster hits. A prominent example is the FORTIFIED program, which is run by the nonprofit Insurance Institute for Business and Home Safety (IBHS). FORTIFIED is a network of contractors who are trained to make home improvements to better prepare a structure for extreme weather. Then, an evaluator inspects the improvements and gives the home a FORTIFIED certification, which improves the chances of a home receiving private insurance. Though FORTIFIED is not required to participate in the NCJUA or NCIUA, it is strongly recommended. The program is an example of state insurance policy catalyzing change to reduce climate risk, a model that should be expanded in the wake of Hurricane Helene.

How different insurance markets are impacted by climate change:

Auto

Climate change is reshaping the auto insurance market in three primary ways. First, it has led to higher premiums in climate-prone areas, mirroring trends in the home insurance market. Damages from severe storms (hurricanes, hailstorms, etc.) and wildfires are the main drivers behind high rates. Another reason behind this trend is that more Americans are switching to electric vehicles (EVs), which tend to have higher insurance premiums. This is due to the higher sticker price of EVs and difficulties in insuring the batteries themselves, which are expensive and fire-prone.

Second, climate-related disasters increase the likelihood of what the insurance industry calls 'secondary perils.' This refers to the increased likelihood of auto accidents due to poor weather, such as flooding, hailstorms, and droughts. Even if the weather does not destroy the vehicle itself, more accidents occur due to the poor conditions. Secondary perils are the main reason why Florida has the third-highest car insurance rates in the nation.

The third issue relates to used car scams that are common in the wake of large natural disasters, such as Hurricanes Helene and Katrina. When a large storm hits, many people abandon their cars, which are likely to experience flood damage during the storm. Once the waters have receded, scammers will clean up the damaged cars, ship them across the country, and sell them to unsuspecting buyers. When these vehicles inevitably malfunction soon thereafter, insurance companies will have to pay out larger-than-normal premiums.

Home

Home insurance is arguably the insurance class most impacted by climate change. Homes are expensive assets tied to a physical location, which exacerbates

climate risk. The two biggest climate threats to American homes are wildfires and floods. Wildfires impact swaths of the American West, most notably California. Population growth and low-density urban development have led developers to build more homes in the wildland-urban interface (WUI), where fire risk is the highest. State Farm stopped offering new homeowners' insurance policies in California after it incurred heavy losses from wildfires (see the fire insurance section for more info).

The vast majority of home insurance policies do not cover floods. Despite this, flooding is the largest natural hazard threat to homes, costing homeowners over $5 billion annually (see the flood insurance section for more info). The three main types of flooding are coastal, riverine, and flash floods. During Hurricane Helene, flash floods were the most severe, as the ground was already saturated from previous rainfall, causing massive flooding in Appalachia's narrow valleys. The statistical probability of the cumulative rainfall across the three days of Helene was 1-in-1,000, making this event virtually impossible for insurance companies to forecast. Only 6% of Americans have purchased flood insurance, leaving most properties with standard home insurance financially vulnerable to flooding catastrophes.

Renters

Renters are often of lower economic status than homeowners, making them less able to afford rate hikes. Climate change impacts renters' finances by both contributing to rising rents and increasing premiums for renters' insurance. Landlords' insurance rates are also rising due to increased climate threats, and landlords have been passing on these higher costs to renters. Even though renters' insurance is less expensive and has lower coverage than homeowners' insurance, climate impacts have led to rising premiums for renters as well. In California, State Farm has requested that regulators allow the company to increase renters' insurance premiums by 52%, higher than the 30% hike proposed for homeowners'

insurance. In short, renters are some of the most impacted by climate risk, yet the least able to respond.

Flood

Unlike in other insurance classes, the private sector is a small player in the flood insurance market, only issuing around 4% of total policies nationwide. Though the private sector has traditionally not engaged with flood insurance, global reinsurers such as Lloyd's are offering private policies that offer enhanced coverage from standard NFIP policies. This strategy is centered around offering comprehensive policies in flood-prone areas like Florida and Puerto Rico.

Private insurers are betting that their advanced modeling and more expansive coverage will justify higher premiums that will enable their business model to be successful. However, these private insurers are selective in their underwriting, primarily catering to wealthier homeowners who want more comprehensive flood protection.

For most Americans who want flood insurance, the NFIP is the most realistic option. The NFIP is a federal flood insurance program administered by FEMA. Created in 1968, the NFIP was envisioned to provide flood insurance to all Americans after the private sector pulled out of the market. The mandate of the NFIP extends beyond providing flood insurance, encompassing flood risk mapping and supporting flood mitigation efforts. In recent years, the NFIP has seen a decline in its number of policyholders, even as the number of properties that have been impacted by floods has increased.

This decrease has been attributed to the rollout of the Risk Rating 2.0 program, which institutes more tailored pricing dependent on individual risk, resulting in higher premiums for many policyholders.

The NFIP faces an uncertain future under the Trump Administration. Because the NFIP must be reauthorized by Congress, it is subject to political forces. The NFIP's authorization briefly lapsed during the 43-day shutdown of the federal government in Fall 2025. As part of the agreement to end the shutdown, Congress

agreed to temporarily extend the NFIP's authorization to January 30, 2026. In the event that the NFIP is not reauthorized before this deadline, FEMA would become the caretaker of existing NFIP policies. However, the agency could not sell new policies or renew current ones, similar to the program restrictions during the shutdown.

The last time the NFIP authorization lapsed in 2010, realtors estimated that the lack of insurance cancelled or delayed 1,421 home sales per day. Given that both the Cato Institute (a conservative think tank) and Project 2025 have called for the elimination of the NFIP, the future of the program is unclear. Since state governments have traditionally partnered with the NFIP to offer flood insurance, it remains to be seen which stakeholders will fill this flood insurance gap.

Fire

Fire protection is usually covered in home insurance policies, except in locations that have a high risk of wildfires. In these locations, a separate fire insurance policy is necessary to protect against fire. The market for stand-alone fire insurance is underdeveloped, leading most homeowners who desire greater fire protection to purchase a more comprehensive (and usually more expensive) home insurance policy. If fire insurance is covered in homeowners insurance, insurers may withdraw the entire home insurance policy simply because of wildfire risk, as has occurred across the American West. Between 2018 and 2023, over 1.9 million home insurance policies were dropped by insurers. Policy nonrenewals are concentrated in fire-prone California and hurricane-prone regions along the Gulf and Atlantic coasts (see Figure 1).

To mitigate fire risk, home insurers are engaging with policyholders to fireproof their properties. This can involve removing debris from around the home, updating structures to comply with building codes, and perhaps most controversially, the use of private firefighters. Some insurance companies have contracted private firefighting companies to defend their clients' properties as wildfires near, which was prominently seen in Pacific Palisades during the Palisades

Fire. But many private firefighters also conduct mitigation activities that reduce fire risk, highlighting how the insurance industry can be a driver of climate resilience.

As with flooding, wildfires are pushing more homeowners towards state-backed insurers of last resort. Fair Access to Insurance Requirements (or FAIR plans) have been implemented by 34 states to operate as insurers of last resort, most notably in California. California's FAIR Plan has grown astronomically, with the program's total exposure reaching $599 billion in March 2025, up 31% from September 2024 and 259% from September 2021. The FAIR Plan in California is financed by charges on private insurance companies, which are passed onto policyholders. In this way, the FAIR Plan creates a vicious cycle in which higher rates lead to more homeowners losing private insurance, resulting in high-risk properties migrating to the FAIR Plan, which in turn leads to even higher private insurance premiums. Furthermore, the California FAIR Plan has limited coverage, is rapidly running out of money in the wake of recent fires, and will now have to pay for smoke damage after it lost a court case in Los Angeles. Reform is needed to make insurers of last resort financially sustainable.

Wildfire risk mitigation is ripe for innovation from startups. Unlike with flooding, in which the NFIP maintains the comprehensive flood map database, there is no equivalent fire risk mapping database. Though the National Interagency Fire Center (NIFC) maintains fire risk maps, these are not detailed enough to provide actionable insights for homeowners and insurers. Startups are filling this gap by developing advanced fire analytics. The Bellwether Project, a spin-out from Alphabet's Moonshot Factory, is using AI-powered models to fill in data gaps in fire maps, allowing for property-level assessments of fire risk. Frontline Fire Defense combines fire tracking software with enhanced on-site sprinkler systems to protect properties from wildfires. Urban Sky is developing a microballoon with advanced sensors that can detect heat signatures at a 10 cm resolution, enabling improved fire response. The playbook of providing advanced analytics to insurance companies should be replicated for other climate threats beyond wildfires.

Businesses

Corporations, especially those with many physical assets, are susceptible to climate-induced insurance rate hikes. Though the U.S. Securities and Exchange Commission (SEC) withdrew its climate disclosure rules in March 2025, other jurisdictions still require companies to report physical climate threats to operations. The European Union's Corporate Sustainability Reporting Directive (CSRD) requires companies to assess and disclose physical climate risks to both their own operations and adjacent value chains. Similarly, California's SB261 directs large companies to disclose climate-related financial risks. Greater climate-related risk transparency may result in higher insurance premiums and higher costs of capital for companies.

Across sectors, insurers are struggling to adapt to new climate threats. Energy insurance has been particularly impacted because of the physical asset-heavy nature of the industry. Many power plants are located along waterbodies due to their need for cooling water, increasing the risk of flooding at these facilities. Oil and gas infrastructure is clustered along the U.S. Gulf Coast, a region that is experiencing more severe hurricanes. Wind and solar facilities are vulnerable to hail damage, ice storms, windstorms and flooding. Utilities face large liabilities when their equipment ignites fires that are exacerbated by climate change, as seen by the 2019 bankruptcy of PG&E due to claims from the Camp Fire.

The energy industry relies on many different types of insurance, including property, liability, business interruption and legal insurance. For many large projects, insurance is offered on an over-the-counter (OTC) basis, with the insurance product tailored to the unique risks of the facility. While OTC insurance policies may offer better price risk than standardized insurance contracts, transaction costs are high, resulting in rising premiums. For example, insurance companies consider offshore wind farms to be inherently risky ventures, as turbines must endure harsh offshore conditions, of which insurers have little data

or precedent to develop actuarial models on. Most energy companies receive policies from large global insurers, such as Zurich Re, Allianz, AIG, Chubb, AXIS Capital, Aviva, Munich Re and AXA XL.

Commercial real estate is another sector heavily exposed to climate risks. Climate risk exposure has a tangible impact on the financial performance of Real Estate Investment Trusts (REITs), as research has demonstrated that REITs with higher climate risk have lower cash flows and firm values. Like homeowners, REITs are experiencing double-digit increases to their insurance premiums, which has led some REITs to introduce 'self-insurance,' which involves creating their own captive insurance solutions. Many REITs are using their extensive resources to better understand climate risk, a market driver that led S&P Global to acquire The Climate Service (TCS), a Durham-based climate analytics company. Due to their diversified portfolios and sophisticated understanding of climate risk, REITs are likely to mitigate climate risk more effectively than most property owners.

On the other hand, small business owners face a more fragmented insurance landscape. Unlike REITs, small businesses are geographically concentrated, meaning that a single natural disaster is more likely to damage all of the businesses' assets. Most small businesses hold business insurance (also known as commercial insurance), which usually covers property damage and loss of business income. Like in other insurance markets, rising premiums and lower coverage due to climate change are resulting in many small businesses losing insurance or self-insuring. Many small businesses devastated by Hurricane Helene did not hold insurance policies, creating insurmountable financial barriers to reopening. According to FEMA, 40% of small businesses fail to reopen after a natural disaster. Many businesses consider utilizing reduced-rate Small Business Administration (SBA) loans to rebuild. Still, even reduced interest payments are too high for many impacted businesses to pay.

Life and Health

Climate change impacts virtually every aspect of our lives, as extreme heat, air pollution, and the increased likelihood of natural disasters reduce life expectancies, even in developed countries. These changes can no longer be ignored by life and health insurers, as climate-induced events are now one of the leading causes of mortality. Of particular concern to insurers are heat-related illnesses, which result in higher hospitalization costs. This dynamic is likely to lead to inequitable outcomes, as outdoor laborers and residents without air conditioning are far more likely to suffer from extreme heat. The insurance industry can take the initiative by supporting preventive programs and developing climate response plans, which will reduce health-related claims.

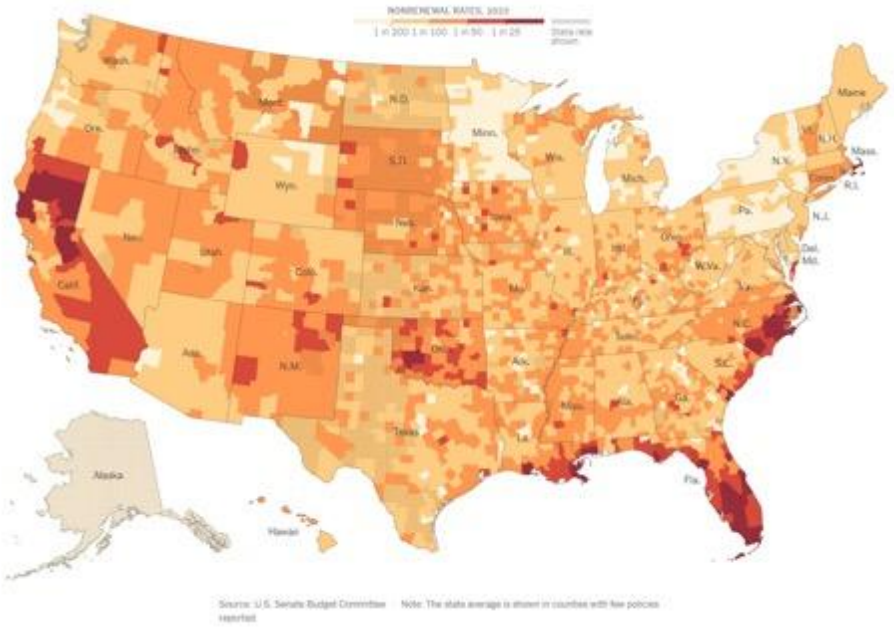

Figure 1: Nonrenewal rates for homeowners' insurance policies across the United States in 2023. Rates are the highest in California, Florida, along the Gulf Coast, and in Eastern North Carolina. Map Source: The New York Times

Risk management responses to climate change

Leaders are facing critical decisions regarding assets with elevated climate risk. Insurers are increasingly less willing to underwrite projects in high-risk zones, forcing organizations to either abandon projects or absorb the risk themselves. Below are examples of how governments and the private sector are rethinking asset management to adapt to climate risks.

Government

Hurricane Helene has forced the state of North Carolina to reconsider how it mitigates risk on flood-prone properties. Governor Josh Stein's request for additional recovery funding to the General Assembly includes a provision that requires school districts to purchase flood insurance for all buildings in a 100-year floodplain. Many school districts are still financially strapped after entire buildings were destroyed by Hurricane Helene and did not purchase flood insurance. The storm has also accelerated timelines for overdue infrastructure improvements and repairs. Also included in Governor Stein's Helene recovery budget request is funding to remove failing dams, improve the Flood Monitoring and Alert Network (FIMAN), and enhance landslide risk mapping. The state's response demonstrates how the next generation of climate-aware asset management relies on augmenting existing infrastructure with improved data and monitoring. Removing compromised dams is essential to averting future disasters, but improvements to FIMAN and landslide risk maps highlight the growing role of improved information gathering in disaster response.

Coastal regions also face chronic climate risks that governments must manage. Sea level rise, coastal erosion and storm surge are all existential threats to oceanfront properties. A proposed solution is managed retreat, the strategic relocation of infrastructure away from areas of natural hazard risk. In a coastal setting, managed retreat often takes the form of government buyouts of coastal properties, proactively placing conservation easements on at-risk land and

relocating critical infrastructure. Government plays an essential role in facilitating managed retreat, both by offering incentives for relocation to private property owners and directing new development to higher ground.

Though managed retreat is politically challenging, the proper structuring of incentives can result in a successful relocation. The Fire Island to Montauk Point (FIMP) Project was a managed retreat program conducted along the southern shore of Long Island, New York, in the aftermath of Superstorm Sandy. FIMP used Sandy recovery funds to pay for residents with properties in the 10-year floodplain to either have their homes demolished, relocated, or elevated. Now, former at-risk neighborhoods have been returned to salt marshes that protect the coastline from future storms. In North Carolina, the National Parks Service has partnered with its NGO affiliate, the National Park Trust, to purchase at-risk properties in Rodanthe. Working with property owners upfront to relocate residences has saved the park beach cleanup and closure costs by preventing the homes from falling into the ocean.

Private Sector

Three main drivers pushing the private sector to mitigate climate risks are regulations, investor requirements and community advocacy. In addition to the earlier-mentioned reporting directives (EU CSRD, California's regulations, etc.), some governments are going further than simply requiring companies to assess climate risk and compelling companies to close high-risk facilities. For example, the El Salvadoran government decided to ban metal mining due to nationwide water shortages associated with climate change. In these cases, scarcities are driven by macro-trends not associated with the actions of individual companies, limiting response options by corporate leaders.

Investor-driven requirements to reduce climate risk are often paired with decarbonization demands. For example, activist shareholders forced oil and gas major Exxon to replace board members with new representatives who are more attuned to climate concerns. While most of the attention was focused on Exxon's

emissions, shareholders are also concerned about the growing physical risks to Exxon's infrastructure. Many of Exxon's facilities are on the hurricane-prone U.S. Gulf Coast and are likely to be damaged in the event of a major storm. Shareholders have required Exxon to create a report detailing the public health risks if a petrochemical facility is damaged and releases chemicals during a storm.

Financial institutions are developing investment strategies centered around accurately pricing climate risk. Delta Terra Capital is a hedge fund whose strategy is to provide market signals for climate risk in real estate and municipal bond markets. This involves shorting properties at risk of sea level rise and flooding and buying climate-secure properties. If more investors engage in this strategy, then developers should receive a lower cost of capital for climate-smart projects.

Community demands are another reason why companies must readjust their asset management strategies. This is especially prominent in real estate, where wealthier developers are attempting to reallocate their assets to higher elevation areas, which tend to be lower-income compared to oceanfront neighborhoods. In the Miami metropolitan area, luxury developers are shifting focus away from oceanfront condos that are at-risk for inundation towards properties further inland. However, lower-income inland neighborhoods are worried that the migration of wealthier residents to higher ground will lead to the gentrification of their communities. Finding a suitable place to relocate to is a major barrier to mitigating climate risk.

Insurance innovations as a response to climate change:

Parametric insurance

Parametric insurance models set pre-defined payouts when an environmental threshold is crossed, such as a certain wind speed or flood height. Unlike traditional insurance, parametric insurance is linked to a specific event, increasing the coverage for the policyholder. Another benefit of parametric insurance is that it increases transparency between the policyholder and the insurance company, reducing bureaucracy and disputes associated with the claims negotiation process. This approach leverages enhanced meteorological monitoring to measure and predict natural disasters, providing a new market for climate intelligence startups. As a result, insurance companies have more data to incorporate into their actuarial models, allowing them to appropriately price insurance policies.

Community-based insurance

Community-based insurance is when a local government or community organization buys insurance on behalf of community members and works to enhance the resilience of the community to mitigate risks. Instituting insurance policies on the community level will especially benefit underserved communities, where individual homeowners may struggle to procure policies due to their elevated climate risk. Furthermore, large-scale resilience activities need collective buy-in from the community that group insurance can provide. For example, a community-based insurance provider in a coastal community could pay for nature-based flood protection and marsh restoration, which would reduce risk for the entire community. A pilot community-based insurance program in New York City, conducted in partnership between SwissRe, the Environmental Defense Fund, and the National Science Foundation, has seen success in enhancing community resilience.

Public-private risk-sharing programs

Public-private partnerships for insurance are a form of blended capital that incentivize private insurers to remain in high-risk areas. Instead of supporting insurers of last resort, the public sector can provide 'first-loss' capital to private insurers, allowing them to remain profitable in disaster-prone areas. The insurance industry could continue to leverage its expertise in risk analysis and the public sector could facilitate the equitable distribution of payouts. A partnership would allow insurance companies to maintain a diversified portfolio to sustain profit margins and use government backing to lower their cost of capital. An example of public-private risk sharing is Flood Re, a joint initiative between the British government and private insurers. Homeowners in flood-prone areas still buy insurance from private insurance companies, but these companies use money from Flood Re to pay claims. Flood Re itself is financed by the insurance policies paid to partner private insurance companies and via a levy instituted on all home insurers in the United Kingdom.

Community engagement from insurers

Insurers have tremendous leverage to catalyze climate resilience activities. Insurance companies can require that homes be upgraded to current building codes and or that a municipality build a new stormwater drainage system as a condition of the insurance policy. In addition to upgrading physical infrastructure, insurers can share their risk analytics insights with communities, allowing stakeholders to make well-informed decisions. In this way, insurers can move the needle to make a material impact on the resiliency of the communities they operate in.

Venture Opportunities for Boosting Resiliency

STEM-based innovators are in an ideal position to provide improved products to help corporations and communities improve their climate resiliency. Below are a few areas where new ventures are making an impact.

Advanced Modeling

In light of federal funding cuts to weather monitoring and disaster response agencies, it is becoming increasingly more challenging for emergency managers to receive accurate information about natural hazards. However, improvements in AI are allowing for more specific and detailed predictions of future weather events. Fathom Science, a Raleigh-based ocean intelligence developer, has built an AI-powered digital twin of the ocean. The system generates real-time metocean forecasts across the global ocean, functioning as an early warning system for hurricanes. Hawaii-based startup Hohonu has built sensors that collect high-quality environmental data and predict flash floods. Hohonu's technology is a vast improvement over generic FEMA flood maps, providing more granular data and forecasting to reflect dynamic flood risks. This technology can be utilized by disaster response agencies to send out more accurate warnings, insurance companies for improved pricing and engineers to develop more effective flood control systems. In the wake of recent botched flash flood responses in Texas Hill Country and in the North Carolina Piedmont, the need for improved weather modeling is all the more apparent.

Grid Resiliency

The infrastructure-heavy nature of the electric power system has resulted in catastrophic power outages during recent natural disasters. In the hardest-hit areas of Western North Carolina, power was out for three weeks in the aftermath of Hurricane Helene. Widespread blackouts during Winter Storm Uri in Texas in 2021

further highlighted the vulnerabilities of the power system to extreme weather. The centralized nature of generation on the current grid contributes to the vulnerability of power systems, as the single point failure of a transmission line can result in blackouts for thousands of customers.

Fortunately, the decarbonization of the grid also contributes to its resiliency. Distributed energy resources (DERs) are a network of small-scale electricity generation systems located close to the end users, reducing the need for long-distance transmission lines. Solar panels and wind turbines combined with robust battery storage systems form the basis of microgrids, localized electricity systems that can operate independently of the centralized grid. Microgrids have kept the lights on even when the larger grid has failed during extreme weather. Despite over 2.7 million Floridians losing power during Hurricane Ian in 2022, the planned community of Babcock Ranch remained electrified thanks to a microgrid powered by solar plus battery storage. As the cost of lithium-ion batteries continues to plummet, distributed networks of renewables and batteries are critical to weathering the next storm.

Improved grid management is another way innovators can ensure resiliency during storms. Utilities collect millions of data points using Supervisory Control and Data Acquisition (SCADA) systems, but are unable to effectively leverage this data to improve operations. GridSeer, a Durham-based startup, has developed an AI-based software suite to optimize power line utilization, integrate renewables, and manage demand response. GridSeer is one of many promising startups in the grid analytics and management space, which has collectively raised $6.4 billion in venture funding.

For improved grid data analytics solutions to be most effective, they need to be paired with smart hardware that can respond to more precise insights. DG Matrix, a Morrisville-based power electronics startup, has built a power router that allows for more effective data center energy management and can incorporate bidirectional charging for electric vehicles. DG Matrix's technology is critical for grid resiliency because it enables power systems to effectively manage loads across

multiple energy sources. Another startup, Durham-based FlexGen, offers a similar solution that is designed for utility-scale as opposed to behind-the-meter applications. FlexGen's technology allows battery developers to sync operations across multiple battery systems, improving the safety and performance of utility-scale batteries. These startups are working to build a more resilient grid by improving system flexibility, redundancy and optimization.

Coastal Resiliency

The dual trends of sea level rise and increasing coastal development are putting more assets at risk of extreme weather, resulting in record levels of property damage during recent hurricanes. Nature-based solutions are highly effective at protecting coastal properties from storms while also restoring natural ecosystems. Innovations in nature-based solutions for coastal resiliency are allowing more property owners to protect their infrastructure at a lower cost.

Natrx Adaptive Infrastructure is a leader in this space, developing a novel living shoreline technology that reduces coastal erosion and protects properties from storm surge. The Raleigh-based startup uses cutting-edge technology, including a 3D printer and LiDAR imagery, to effectively deploy shoreline stabilization solutions. Major ports and energy companies are using Natrx's technology to protect their coastal facilities. Similar to Natrx, the Sandbar Oyster Company is using natural systems to help restore shorelines and protect coastal properties.

The Morehead City-based company has invented a biodegradable material, Oyster Catcher™, to promote oyster reef growth. Healthy oyster reefs reduce wave energy, limiting the shoreline erosion and wave energy that a property experiences. Startups leveraging nature to protect coastal communities will be in high demand as hurricanes become more frequent and severe.

Novel Insurance Products

New insurance business models are needed to support the energy transition and better manage climate risk. Credit risk is a roadblock for many small businesses to install renewable energy, such as rooftop solar. Energetic Capital solves this challenge by providing credit insurance for renewable energy project loans, allowing businesses to install renewable energy systems that they otherwise would not be able to afford.

On the nature-based solutions front, new insurance products are being created to protect natural ecosystems. For example, The Nature Conservancy has partnered with global insurance provider AXA XL to develop mangrove insurance. Mangrove insurance offers payouts to mangrove restoration developers if their project is destroyed by severe weather. In this way, mangroves could be rapidly restored so that they can continue to protect coastal communities. Municipalities pay into a trust fund, which hires contractors to restore mangroves and purchases parametric insurance for the mangroves.

Private insurers are beginning to offer parametric insurance products as a response to climate risk. Ibisa is a Luxembourg-based parametric insurance provider that is working with farmers to protect crops using remote sensing and blockchain technology to streamline operations. New York-based Arbol develops products specific to climate risk, allowing clients to set their own payout parameters tied to certain weather events (e.g., a certain amount of rainfall or wind speed). Descartes, based in Paris, uses a similar approach that incorporates real-time meteorological data and advanced climate modeling to improve parametric insurance.

Conclusion

The unprecedented scale of extreme weather has made managing risk more challenging. Yet, innovations in the insurance industry are enabling communities to adapt to climate risk effectively. Parametric insurance, community-based insurance, public-private risk-sharing programs and community engagement from insurers are all business model advances that allow communities to bounce back from disasters. The next era of insurance will be reliant on advanced modeling and analytics, which will provide an information backbone for insurers, asset managers and governments alike to assess risk. As North Carolina rebuilds from Hurricane Helene, state leaders must develop resilient infrastructure and economic models that will weather the next storm.