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Climatic Events, Inequities, and Risk Mitigation

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Introduction

Climatic events and climate change do not impact all communities equally.[1] Disadvantaged populations and the communities they live in experience a significant burden. As a result, populations that disproportionately experience the adverse impacts of climate change include people with low socioeconomic status, children, people with disabilities, the elderly, and many rural populations. The impacts can come in many forms—from the fundamentals of survival such as shelter, health, and economic viability to the challenges of preparing for extreme events such as tornadoes, hurricanes, wildfires, and extreme heat through insurance and other forms of financial planning.

Actuaries are often charged with modeling and pricing the security systems designed to protect the general population from the adverse financial impacts of climatic events. As a result, actuaries are well positioned to provide input related to developing means of reducing the inequities of climate-related disasters. In addition, actuaries can work together with policymakers and other professionals to estimate financial impacts of mitigation strategies, providing input on potential alternative financing approaches.

This issue paper focuses on the cause-and-effect relationship that different climatic events such as wildfires, floods, hurricanes, and extreme heat have on different U.S. populations and communities that disproportionately experience the effects of climate change. These disasters have impacts that can be broadly shared across communities. The issue paper also:

- Delves into the climate impacts on two critical variables for these populations—health and water availability;
- Identifies some shortfalls of current climate disaster responses;
- Proposes a few possible public and private insurance-type solutions; and
- Describes other risk-mitigation approaches.

1 The term "climatic event" in this paper refers to an extreme event itself, not confined to weather, but also may include a wildfire, ice storm or other event that is naturally occurring. Not all of these events individually will be attributed to climate change (like an individual storm or wildfire).

Infrastructure and resiliency

For a community or individual, the financial security associated with climatic events and climate change is not only related to an individual's income, savings, and insurance profile, but also the resilience of the community social structure and the strength of the infrastructure supporting the community. A community's infrastructure includes both public and governmental infrastructure as well as private/corporate infrastructure providing water, sewer, roads, electric and gas utilities, and health facilities, to name a few. Nonfinancial aspects such as community social resources and resilience are of key importance but are not addressed here. While the focus of this issue paper is not directly on the sustainability and resilience of the infrastructure, there is an interrelationship between the infrastructure and the issues of equity in the face of extreme and changing climatic events. As a result, the issue paper refers to infrastructure from time to time, but its focus is on the financial implications.

This issue paper describes localized short-term impacts of acute events as well as the more dispersed long-term impacts of climate change that can manifest as an increased frequency and severity of climatic events that have a cumulative financial impact. Adaptations that may reduce the financial consequences of particular types of events may result in increased resiliency.

Intended audience

This issue paper explores considerations for actuaries, including an introduction to the range of equity issues that climatic events—particularly an increasing propensity of specific types of events—may pose to the work of actuaries. The audience includes actuaries, policymakers and regulators, along with other interested parties. Policymakers and regulators, as well as actuaries, can use information contained in this issue paper about the potential equity issues associated with climatic events and climate change *trends* to produce more effective regulations, policies, and risk mitigation strategies.

Connecting climate events to equity issues

Climate-related inequity arises when households lack financial resources for disaster recovery (from savings, insurance, and the receipt of governmental grants) and also lose the ability to maintain financial security programs. When a climate-related natural disaster occurs, the populations that disproportionately experience the effects of the event(s) are financially constrained and are not able to move to alternative locations, prepare when early warnings come, or afford to rebuild or find rental properties near their former homes. Vulnerable populations are often more likely to be diagnosed with the health issues negatively impacted by the event such as mental illness, mobility issues, and chronic illnesses. When inequity exists, households disproportionately exposed to climate risk may also have a disproportionate inability to afford to pay premiums for insurance coverages of all types. The family may lapse its insurance protection, thereby forfeiting future reimbursements for losses resulting from death, critical illness, or disability of a family member. The inability to make future contributions to retirement savings programs including 401(k)s and IRAs jeopardizes the amount of funds available for retirement.

Due to the immediate need for liquidity, policyholders may surrender or borrow amounts from their insurance and retirement contracts focusing on immediate survival concerns.

Without safeguards to protect victims of catastrophic events, the dollar magnitude of current and future losses will make it difficult for households to recover.

Climate, health, and property—setting the stage

Health

Weather-related health issues are not new. Floods, tornadoes, and hurricanes have always been associated with injury and death. As extreme weather events, due to long-term climate change, increase in frequency and severity, more persistent health impacts will need to be understood. In the United States, climate change has already caused numerous health impacts, affecting both physical health and mental well-being. While individual experiences may vary, there is a strong connection between climate-related impacts and already existing social determinants of health (non-medical factors impacting health like socioeconomic status, availability of shelter to name a few).[2]

2 "*Social Determinants of Health*"; CDC Public Health Professionals Gateway; May 15, 2024.

The following are broad categories of health impacts when considering the ways climate change impacts human health.

- Extreme weather events: Rising global temperatures contribute to an increase in extreme weather events such as hurricanes, floods, wildfires, and heat waves. These events can cause injuries, displacement, and fatalities, as well as disrupt essential services like health care, clean water, and sanitation.

- Heat-related illnesses: As temperatures rise, heat-related illnesses like heat exhaustion and heatstroke become more common.[3] Populations vulnerable to heat-related conditions—including the elderly, children, and individuals with chronic health conditions—are particularly at risk. Heat waves can worsen existing cardiovascular, renal, and respiratory conditions. Heat events may be associated with poor maternity outcomes.[4, 5, 6]

- Air quality and respiratory issues: Climate change can worsen air quality, leading to increased respiratory problems such as asthma, chronic obstructive pulmonary disease (COPD), allergies, and other respiratory infections. Wildfires, which are exacerbated by climate change, release harmful pollutants into the air, further expanding the number of people experiencing respiratory issues. Drought increases dust and airborne particles, which can impact respiratory disease or even increase the prevalence of such diseases as valley fever.[7, 8, 9, 10, 11, 12]

- Vector-borne diseases: Climate change influences the distribution and behavior of disease-carrying vectors like mosquitoes and ticks. Warmer temperatures and altered precipitation patterns can expand the geographic range of these vectors, increasing the risk of diseases like Lyme disease, West Nile virus, Zika virus, and dengue fever.[13, 14, 15]

3 While this paper focuses on heat-related impacts rather than cold weather-related impacts, cold weather deaths have been increasing, as noted by the Environmental Protection Agency.
4 "The Impact of Heatwaves on Mortality and Morbidity and the Associated Vulnerability Factors: A Systematic Review"; *International Journal of Environmental Research and Public Health*; December 2022.
5 "Heat and health"; World Health Organization; May 28, 2024.
6 "Temperature Extremes"; CDC Climate and Health; March 2, 2024.
7 "Health and Environmental Effects of Particulate Matter (PM)"; U.S. Environmental Protection Agency; July 16, 2024.
8 "Recent Insights into Particulate Matter (PM2.5)-Mediated Toxicity in Humans: An Overview"; *International Journal of Environmental Research and Public Health*; June 2022.
9 "Inhalable Particulate Matter and Health (PM2.5 and PM10)"; California Air Resources Board; undated.
10 "Wildfire smoke impacts respiratory health more than fine particles from other sources: observational evidence from Southern California"; *Nature Communications*; March 5, 2021.
11 *Wildfire Smoke Guide* (chapters 1-3); AirNow.gov; May 2021.
12 "Impacts of Fine Particulate Matter From Wildfire Smoke on Respiratory and Cardiovascular Health in California"; *Geohealth*; June 2022.
13 "Climate Crises and Developing Vector-Borne Diseases: A Narrative Review"; *Iranian Journal of Public Health*; December 2022.
14 "Climate Change and Vectorborne Diseases"; New England Journal of Medicine; November 23, 2022.
15 "Climate change: an enduring challenge for vector-borne disease prevention and control"; *Nature Immunology*; April 20, 2020.

- Waterborne illnesses and water quality: Changing precipitation patterns, leading to flooding and rising sea levels, can impact water quality, leading to an increased risk of waterborne diseases such as cholera, diarrhea, and other gastrointestinal illnesses. Drought and water shortages can impact hygiene, which is particularly worrisome for those with gastrointestinal and skin conditions.[16, 17, 18]

- Mental health impacts: Climate change-related events, such as natural disasters and prolonged periods of extreme weather, can lead to psychological distress, anxiety, depression, and post-traumatic stress disorder (PTSD) in affected individuals. Displacement, loss of homes, and disruption of communities can further contribute to mental health challenges. There is some evidence that climate dread is having a negative impact on mental health in younger populations. Some studies indicate that there may be an increase in violence in general when there are heat events. Mental health issues persist long after the climate event is over.[19, 20]

- Food security and nutrition: Climate change affects agricultural productivity, which may lead to crop failures, changes in food availability, and increased food prices. These disruptions undermine food security and nutrition, impacting physical health and development, especially in vulnerable populations.[21]

- Housing uncertainty: Homelessness and lack of safe, secure housing have been shown to negatively impact health. Many of the climate impacts on housing are disproportionately borne by those who are already economically challenged—a subset of the population already overburdened with the very chronic diseases that are directly impacted by climate events.[22]

The health impacts of climate change are interconnected and can have cascading effects. When there is a continuous flow of events, such as the repeated atmospheric rivers on the West Coast or multiple years of drought, rather than sporadic isolated events, health systems and personal health status may not have the means to recover. Household, business, and municipal budgets may be able fund the recovery from a wildfire, but in doing so have reduced resources for the next event.

16 "Climate Change Impacts on Waterborne Diseases: Moving Toward Designing Interventions"; *Current Environmental Health Reports*; June 2018.
17 "Waterborne Diseases in a Changing Climate"; *Microcosm*; Spring 2022.
18 "Water-related Illnesses"; National Institute of Environmental Health Sciences; June 12, 2024.
19 "Why mental health is a priority for action on climate change"; World Health Organization; June 3, 2022.
20 "Mental health effects of climate change"; *Indian Journal of Occupational and Environmental Medicine*; January-April 2015.
21 "Food Security"; *Climate Change and Land*; The Intergovernmental Panel on Climate Change; 2019.
22 "Findings on Disproportionate Risks of Climate Change to Low Income Individuals"; U.S. Environmental Protection Agency; September 2021. "Climate Equity"; U.S. Environmental Protection Agency; January 2, 2024.

From a health actuarial perspective, sudden events may have readily identifiable costs in emergency room visits, mortality statistics, or admissions, with diagnoses that specifically note such conditions as heat exposure, smoke inhalation, or death by drowning. More persistent impacts will be more difficult to quantify. Long-term chronic health issues will gradually manifest themselves in the experience data; however, direct attribution of changes due to climate may not be evident or even possible.

Property

Hurricanes can cause significant damage that can severely affect people's lives. Homes and businesses can be damaged or destroyed, leaving residents homeless and employees without jobs. Infrastructure can be damaged, leaving areas without power or water. The costs of bringing people back to where they were before the storm can be substantial.

While these costs are suffered by all in the path of the storm, the costs are not borne evenly among all parts of society. As mentioned earlier, disadvantaged communities are more vulnerable to the risks of natural disasters, and they also struggle most to recover. This impact ranges from the lower uptake of property insurance,[23] residences that are not as resilient through age or construction, or loss of employment.

Studies have suggested that areas that do not adapt to natural disaster risk will become poorer over time, as wealthier residents move away from the disaster zone.[24, 25] Some research also suggests that people with lower incomes are less prepared for disasters than others.[26, 27, 28]

Shortly after a large hurricane, there will certainly be a spike in unemployment rates as affected businesses will be closed for some time. This will be very noticeable in coastal communities that depend on tourism, which is very dependent on a lower-wage workforce.[29]

Following a disaster, people with lower socioeconomic status may face additional barriers when seeking aid intended to help them rebuild their homes and meet their other immediate needs. The stress linked to lack of resources may also contribute to emotional and behavioral health consequences.

23 *Homeowners Perception of Weather Risks*; Insurance Information Institute; 2023.
24 "Natural Disasters by Location: Rich Leave and Poor Get Poorer"; Scientific American; July 2, 2017.
25 *Greater Impact: How Disasters Affect People of Low Socioeconomic Status*; Disaster Technical Assistance Center Supplemental Research Bulletin; SAMHSA; July 2017.
26 "Hurricanes hit the poor the hardest"; Brookings Institution; September 18, 2017.
27 "How Natural Disasters Disproportionately Affect Vulnerable Communities"; Environment 911; March 31, 2021.
28 "From Poverty to Disaster and Back: a Review of the Literature"; *Economics of Disasters and Climate Change*; April 24, 2020.
29 "Tens of thousands likely jobless after Hurricane Ian, economists say"; *CNN Business*; October 12, 2022.

Wealthier homeowners and corporations are more likely to have insurance that is adequate to recover from the disaster. People without savings or insurance to rebuild may be forced to relocate, adding additional unplanned financial and social strain. As climate change magnifies the intensity and frequency of extreme weather events, relocation itself can create a vicious cycle negatively influencing the financial stability of lower-income households.

Transformation from isolated events to observable trend

Trends

When a trend of similar and/or connected events occurs, the scenario shifts from a reactive approach to one that is more proactive, reflecting an ability to anticipate and plan for adverse impacts. Individuals who are not in a position to avoid, adapt, or build resilience to these trends need assistance—especially financial assistance. Actuaries can help forecast frequency and severity of economic impacts, allowing public policy efforts and resources to be appropriately focused.

Trends can occur in several ways. Certain geographic areas could be more prone to repeated impacts. Cause and effect can occur, such as one peril making another peril more likely. When insurers recognize a shift in the distribution of the likelihood of a peril, a resulting reaction may be to change where and how the insurer does business. For example, noting trends of wildfire or hurricanes in an area, insurers may limit business in those impact-prone areas by changing policy coverage provisions or adjusting premiums due to the new expectations of loss. As a result, the availability and affordability of insurance is impacted.

Examples of specific climate events that contributed to inequity

In October 2020, Hurricane Delta came ashore in Louisiana about 15 miles from where Hurricane Laura had come ashore six weeks earlier.[30] In the months following these events, this same area near Lake Charles, La., was hit by freezing temperatures and ice in February, followed by more than 12 inches of rain on a single May day, the largest single-day rain event in 41 years.[31] These four events occurred over eight months, near a single city.

A few general lessons were learned about inequities following a hurricane. Populations with lower socioeconomic status often live in the areas more susceptible to storms (as with other natural disasters), have less insurance coverage, and find it less easy to relocate.[32]

30 "Hurricane Delta inflicts new damage on storm-weary Louisiana"; Associated Press; October 9, 2020.
31 "Life In Louisiana's Forever Storm"; The Weather Channel; September 8, 2022.
32 "Hurricanes hit the poor the hardest"; op cit.

A scenario of high weather instability in which the atmosphere becomes very unstable is often called a "loaded gun scenario."[33] The term also describes the situation of living in an area where extreme weather seems to occur more often, leaving residents "under the gun," just waiting for extreme weather to occur. For example, on July 19, 2023, heavy rain in excess of 11 inches fell near Mayfield, Ky., setting a new 24-hour rainfall record in the state. Mayfield was also ground zero for an EF4 tornado that was part of a series of tornadoes that ripped through five states, killing 70 people in Kentucky in December 2021.[34] As equity issues related to tornado impacts are considered, those able to afford insurance are most likely to rebuild and "return to normal," while those who rely on federal or state disaster aid have a more difficult time, due in large part of having to make sense of a fragmented tapestry of aid-supplying agencies.[35]

Another example of an event trend is the atmospheric rivers that hit the West Coast of the U.S. in late 2022 and early 2023. The National Oceanic and Atmospheric Administration (NOAA) defines atmospheric rivers as "relatively long, narrow regions in the atmosphere—like rivers in the sky—that transport most of the water vapor outside of the tropics."[36] Some 31 atmospheric rivers hit California during this time. The cause for the intensity of the atmospheric rivers during this period is not exactly known, but some experts believe it was related to the amount of water vapor in the atmosphere. The volume of vapor could be attributed to a volcanic eruption or the transition from La Niña to El Niño or even due to warmer sea temperatures.[37]

Associated equity issues of atmospheric rivers relate to water management. Atmospheric rivers can be both positive, as they bring a large amount of water for areas impacted by droughts, and negative, leading to flooded areas where water management is limited. Given this disparate and real impact on the population, it is important to include physical scientists as well as social scientists in any public policy discussion when considering how best to manage the large rainfall amounts brought about by atmospheric rivers. Finding ways to harness the positive drought-relief potential in the face of the damage that can result from the intensity of these events is a difficult exercise—one which requires collaboration, further understanding, and planning.[38]

33 "Loaded gun theory"; EUMe Train; 2006. An alternative definition of loaded gun is "a sounding characterized by extreme instability but containing a cap, such that explosive thunderstorm development can be expected if the cap can be weakened or the air below it heated sufficiently to overcome it (National Weather Service).
34 "'This is a setback': Mayfield deals with significant flooding 18 months after deadly tornado"; Fox Weather; July 19, 2023.
35 "How 2 cities rebuilt after tornadoes and why they may be models for others"; ABC News; March 28, 2023.
36 "What are atmospheric rivers?"; National Oceanic and Atmospheric Administration; March 31, 2023.
37 "Volcano? Climate change? Bad luck? Why California was hit with 31 atmospheric river storms"; *Los Angeles Times*; April 11, 2023.
38 "Atmospheric Rivers—Weather, Climate, & Societal Interactions"; National Oceanic and Atmospheric Administration; undated.

Community economic vitality in these areas can decay as those who are able to relocate do so, while those who cannot relocate remain in the higher-risk area. Alternatively, in desirable coastal communities or scenic mountain areas, those who can afford to self-insure may do so. However, the unavailability of appropriate levels of insurance coverages means populations are unable to remain in place or, if they do stay, face an inability to obtain insurance. This has been seen in areas of Indiana, Kentucky, and Tennessee, as flooding in areas with small waterways due to high local rainfall in a short timeframe occurs in areas less able to afford to rebuild or respond to the damage.[39]

Disaster responses

In August 2023, *The New York Times* led its front page with the following headline: "With Breathtaking Speed, Blast of Fire Erases a Town in Hawaii." Hawaii Gov. Josh Green stated that the fire on the island of Maui was "likely the largest natural disaster in Hawaii state history." The community of Lahaina was gutted by the firestorm, a grassland wildfire that became a house-to-house urban inferno. Damage arising from the Lahaina firestorm was estimated in August 2023 to be $5.5 billion, impacting thousands of households.[40] Recovering from this catastrophic event will likely take years—and addressing the physical and mental health of the community will likely take longer.[41, 42]

The Lahaina disaster involves "covariance risk," a catastrophic loss that is extremely broad. These losses are experienced by multiple components as well as the individuals within the community simultaneously. This contrasts with "idiosyncratic risk," which refers to individual household risks normally covered by traditional property and casualty insurance products.

A natural disaster similar to the Lahaina fire may bring a significant negative impact to a community, resulting in reduced employment and increased expenditures. Most households and local businesses of Lahaina experienced significant financial and personal loss from this disaster, with rebuilding taking a long time. When a community lacks sufficient resources, a gap is created. This shortfall requires financial resilience in order to sustain daily living.

39 "Flooding Hits American Towns Far From Oceans and Big Rivers"; *The Wall Street Journal*; June 19, 2023.
40 "$5.52 billion estimated cost to rebuild Lahaina after fire"; KHON2; August 12, 2023.
41 "Maui wildfires lead to dire mental health crisis in Lahaina"; *NBC News*; November 5, 2023.
42 "Five Months After the Fire: Five Takeaways from Maui's Recovery"; Bipartisan Policy Center; January 18, 2024.

"Protection gap" is a term being used increasingly to describe a shortfall, or gap, between insured losses and total economic losses.[43] This gap, impacting households and small businesses, arises when insurance proceeds potentially supplemented by additional sources of recovery (such as charitable distribution and governmental grants) are not sufficient to cover post-disaster recovery cost.

Losses arising from climate-related disasters will impact all residents and businesses residing in the local community. A gap in insurance coverage for many individuals can adversely impact the long-term financial viability of the community.

Disaster recovery expenses

The United Nations Office for Disaster Risk Recovery indicated that the presence of climate-related disasters impacts less-developed countries disproportionately, with the implication that it may result in increased levels of poverty.[44] While the financial inequities of climate change and climatic events are global as indicated by the cited United Nations document, this paper's focus is on the United States. Consequences of poverty create daily risk of insufficient food, lodging insecurity, lost income resulting from job loss, and inability to pay for health care and disaster costs.

Disasters require immediate availability of funds for the payment of expenses for temporary housing, home repair, relocation, travel, and replacing goods lost in the disaster. As an example, an immediate cost for the residents of Puerto Rico after Hurricane Maria was the purchase of generators to provide refrigeration, air conditioning, and heat for an extended period.[45]

Post-disaster costs cover a large range of types of cost impacting individuals and the community related to disaster response costs (temporary lodging, meals, generators, supplies), property costs (repairs, relocation, higher rent, debris cleanup), and broader financial impacts (decreased employment, consumption of savings, additional debt).[46] Business-related recovery costs impact the financial viability of the business resulting from the loss of revenue or potentially leading to bankruptcy.

43 "Insurance Protection Gap Is Growing Global Problem; Swiss Re, RenRe & WTW Comment"; *Insurance Journal*; January 17, 2018.
44 *Integrating Disaster Risk Reduction into the Fight Against Poverty*; Global Facility for Disaster Reduction and Recovery; 2009.
45 "Powerless Puerto Ricans huddle around their generators"; Yahoo News; October 9, 2017.
46 "Can Parametric Microinsurance Improve the Financial Resilience of Low Income Households in the United States?" Carolyn Kousky, Helen Wiley, and Len Shabman; March 23, 2023.

Insufficient recovery resources

Recovery resources can be insufficient for lower-income populations due to several considerations: the availability of individual and community savings to fund recovery, the resulting slower recovery from disasters, and the high proportion of renters.

Low-income families typically have limited savings and may not be able to cover the cost of disaster recovery.[47] To put it in more direct terms, roughly 40% of households do not have $400 of liquid funds for an emergency.[48] In an emergency, households may turn to friends or family for assistance, but in a disaster, entire neighborhoods may be hit simultaneously—making availability of funding more difficult. After Hurricane Harvey, a limited number of people received assistance from a charitable organization to fill in some of the gaps.[49] Ability to borrow funds may be a limited option for low-income population groups that may have low credit ratings or do not meet debt-to-income qualification requirements.

Residents with lower incomes recover less quickly from natural disasters when compared with residents with higher incomes.[50] Slower recovery is also present in communities with greater racial or ethnic diversity and areas with low-cost rental units.

Low-income renters face post-disaster challenges—and with renting at a 50-year high, this impacts a significant population; 36% of households are rental units.[51] While renters are not responsible for the costs of building, renters may have to pay higher rents to fund repairs, or due to a high demand for rental units.[52] Once a unit is uninhabitable from a storm or other natural disaster, residents can be evicted.[53] After a disaster, higher rents impact not just individuals, but also businesses, further impacting the local economy and contributing to the loss of jobs.[54] These dynamics of the rental market imply that the supply shrinks and the cost to rent increases dramatically after a disaster, yielding potentially inequitable results including compromised health of renters.[55]

47 *Lending as recovery policy: Evidence from household applications to the U.S. Federal Disaster Loan Program* (working paper); Collier BL, Ellis CM; 2020.
48 *Increasing the Financial Resilience of Disaster-affected Populations*; Feinstein International Center; 2009.
49 *One Year After the Storm: Texas Gulf Coast Residents' Views and Experiences with Hurricane Harvey Recovery*; Kaiser Family Foundation; August 2018.
50 "Disaster disparities and differential recovery in New Orleans"; *Population and Environment*; January 9, 2010.
51 "More U.S. households are renting than at any point in 50 years"; Pew Research Center; July 19, 2017.
52 "Inequities in Long-Term Housing Recovery After Disasters"; *Journal of the American Planning Association*; 2014.
53 *Evicted*; Matthew Desmond; 2017.
54 "As Disaster Costs Rise, So Does Inequality"; *Journals of the American Sociological Association*; December 4, 2018.
55 "Rent affordability after hurricanes: Longitudinal evidence from US coastal states"; *Risk Analysis*; October 4, 2023.

Federal disaster recovery aid and race inequalities

Federal disaster aid provides limited funding, which may not be sufficient for low-income households. Federal Emergency Management Agency's (FEMA) federal assistance is provided after large disasters that receive a presidential disaster declaration. FEMA is authorized to provide grants to households averaging several thousand dollars. The FEMA website in multiple places emphasizes that FEMA disaster relief is not insurance, does not fully indemnify individual for their losses, but instead may provide basic assistance.[56]

The U.S. Department of Housing and Urban Development (HUD) also provides funding during presidential disaster declarations, but it can take time for funds to reach households and communities. The purpose of funding is long-term recovery, and it is not intended[57] to meet the short-term financial needs of households.[58] There have been concerns raised that funds available for Hurricane Sandy and other natural disaster were distributed inequitably, implicitly favoring white and more affluent homeowners and not meeting the needs of renters and more disadvantaged residents.[59]

Examples of events and variables—wildfires, hurricanes, heat, and water

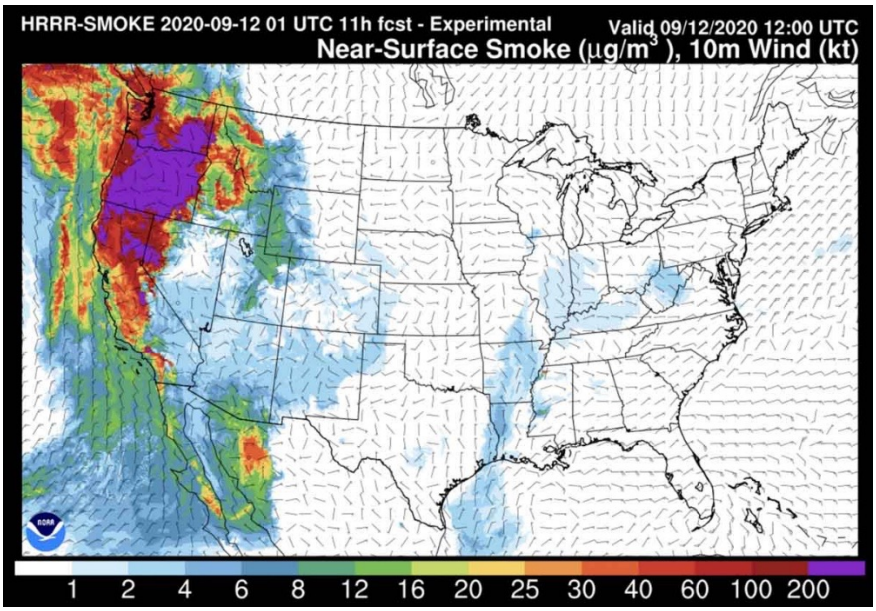
This next section of the issue paper will focus on examples of events and impacts including wildfires and human health, hurricanes and property damage, heat impacts on health including workers, and water availability and quality impacts. Cold weather events and convective storms, to name a few additional types of events, are not included.

Wildfires and human health

Wildfires impact more than property. They also significantly impact human health both directly and indirectly, with a disproportionate impact on populations that may already be struggling. The effects can vary depending on the size and intensity of the wildfire, the proximity of human settlements, the geography, and the weather conditions. Listed below are some ways wildfires can affect human health and noting the disproportionate effect on disadvantaged populations that can lead to further financial inequities both in the immediate aftermath of the event and on a longer-term basis:

56 "Questions and Answers About FEMA Disaster Assistance"; Federal Emergency Management Agency; U.S. Department of Homeland Defense; October 11, 2022.
57 "Let the rich be flooded: The distribution of financial aid and distress after Hurricane Harvey"; *Journal of Financial Economics*; November 2022.
58 *National Advisory Council—Report to the FEMA Administrator*; Federal Emergency Management Agency; U.S. Department of Homeland Defense; November 2020.
59 "How FEMA Can Prioritize Equity in Disaster Recovery Assistance"; Center for American Progress; July 19, 2022.
"Assessing distributive inequities in FEMA's Disaster recovery assistance fund allocation"; *International Journal of Disaster Risk Reduction*; May 2022.

- Respiratory Issues: Wildfires release a large amount of particulate matter, smoke, and other air pollutants into the atmosphere. These tiny particles can be inhaled deeply into the lungs, causing or exacerbating respiratory problems, especially in populations already susceptible to respiratory issues such as children, older adults, and individuals with pre-existing respiratory conditions like asthma or chronic obstructive pulmonary disease (COPD). The National Oceanic and Atmospheric Administration (NOAA) has data visualization tools that track smoke at various elevations indicating that particulate matter from a significant wildfire event can stretch for hundreds—or even thousands—of miles.[60]



- Cardiovascular Problems: Particulate pollution is not only a threat to respiratory health; it is also a contributor to heart conditions such as ischemic heart disease, irregular heart rhythm, heart failure, and pulmonary embolism and stroke.[61] The smoke from wildfires contains harmful chemicals, such as carbon monoxide and volatile organic compounds, which can enter the bloodstream and affect cardiovascular health. The most severe of these impacts are experienced by people in the immediate locality of the fire. A study published in the *Journal of the American Heart Association* in 2020 found that exposure to heavy smoke during wildfires raised the risk of out-of-hospital cardiac arrests up to 70%.[62] The risk was elevated among men and women, among adults 35-64 years old and in communities with lower socioeconomic status. Furthermore, ER visits increased 42% for heart attacks and 22% for ischemic heart disease within a day of exposure to dense

60 The data visualization tools are available here.
61 "Recent Insights into Particulate Matter (PM2.5)-Mediated Toxicity in Humans: An Overview"; op cit.
62 "Not Just the Lungs: Wildfire Smoke May Increase Heart Risks"; AARP; June 9, 2023. "Out-of-Hospital Cardiac Arrests and Wildfire-Related Particulate Matter During 2015–2017 California Wildfires"; *Journal of the American Heart Association*; April 15, 2020.

wildfire smoke. The increase was most notable for adults age 65 and older, according a study published in the *Journal of the American Heart Association* in 2018.[63]

- Irritation and Eye Problems: Smoke and ash from wildfires can irritate the eyes, leading to redness, itching, and discomfort. People with existing eye conditions may experience more severe symptoms. Masking can protect the heart and lungs from particulate matter, but not the eyes. Long-term exposure increases the risk of inflammation to the eyes.

- Mental Health: Increasingly, climate event victims have a range of mental health "from anxiety after hurricanes to surges in suicide during heat waves"—that the nation's disaster response agencies are ill-prepared to treat.[64] Wildfires can cause significant stress, anxiety, and fear among affected communities. Evacuations, loss of property, and uncertainty about the future can contribute to mental health issues such as post-traumatic stress disorder (PTSD), depression, and other psychological impacts. The Paradise California fire has been studied and found that social vulnerability shaped the impacts.[65,66] An Associated Press story reported in November 2023, five years after the fire: "The Camp Fire destroyed about 11,000 homes, which amounted to about 90% of the town's structures. So far 2,500 homes have been rebuilt. About 700 are under construction at any one time, many on original lots. But just six of the town's 36 mobile home parks that served mostly low-income and older residents have reopened." Often the impacted communities are small, tightly woven communities; the destruction of the community is a profound loss for the residents.[67]

- Heat-Related Illnesses: Wildfires can elevate ambient temperatures in surrounding areas, leading to heat-related illnesses like heatstroke, dehydration, and heat exhaustion. Heat-related issues affect the firefighters and first responders who work long hours in the face of the flames as well as residents who are loath to leave their homes and animals and remain despite increasing temperatures.

63 "Cardiovascular and Cerebrovascular Emergency Department Visits Associated With Wildfire Smoke Exposure in California in 2015"; *Journal of the American Heart Association*; April 11, 2018.
64 "A deadly wildfire traumatized their town. Can nature help them heal?"; *The Washington Post*; December 9, 2022.
65 "Wildfire impacts on education and healthcare: Paradise, California, after the Camp Fire"; Natural Hazards; October 9, 2021.
66 "Health and social impacts of California wildfires and the deficiencies in current recovery resources: An exploratory qualitative study of systems-level issues"; PLoS One; March 2021.
67 "5 years after California's deadliest wildfire, survivors forge different paths toward recovery"; Associated Press; November 7, 2023.

- Spread of Infectious Diseases: Wildfires can disrupt communities, displace people from their homes, and expose them to unclean conditions. These factors can facilitate the spread of infectious diseases, particularly in evacuation centers or temporary shelters.[68]

- Water Contamination: After a wildfire, rain can wash ash and debris into water sources, contaminating drinking water and increasing the risk of waterborne diseases. After the fires are extinguished, destabilized forest environments can threaten water storage due to landslides and dam collapse.

- Disruption of Health Care Services: Wildfires can damage health care facilities, force evacuations of hospitals and medical clinics, and strain emergency services, making it difficult for people to access necessary medical care when they need it the most.

- Long-term Health Impacts: Exposure to wildfire smoke and its associated pollutants can have long-term health effects, including decreased lung function and an increased risk of chronic respiratory diseases.[69]

- Social Determinants of Health Exacerbation: Housing, community connections, and access to care are negatively affected as fires destroy housing and cause displacement. This sort of disruption not only affects current health care treatments but may increase vulnerability for poor health and worsen long-term health.

Hurricanes and property damage

Hurricanes bring strong winds and storm surge, causing significant damage to property, including infrastructure, as well as injury and death. They are the costliest type of storm, causing property damage costing billions of dollars in large events. For instance, Hurricane Katrina, which hit New Orleans and the nearby Gulf Coast, caused damage estimated to be about $125 billion in late August 2005. As a result, 1.36 million people filed for FEMA assistance.

68 "Outbreak of Norovirus Illness Among Wildfire Evacuation Shelter Populations — Butte and Glenn Counties, California, November 2018"; *Morbidity and Mortality Weekly Report*; U.S. Centers for Disease Control and Prevention; May 22, 2020.
69 "Wildfire smoke impacts respiratory health more than fine particles from other sources: observational evidence from Southern California"; op. cit.

The following chart shows the seven most costly U.S. hurricanes, all since 2005.

US Hurricanes over $50B Damage			
Name	**Estimated Nominal Damage - $B**	**Year**	**Landfall Location**
Katrina	125.0	2005	New Orleans; Biloxi, MS
Harvey	125.0	2017	Houston
Ian	111.8	2022	Southwest FL
Maria	90.0	2017	Puerto Rico
Irma	50.0	2017	Central FL
Ida	73.6	2021	Western Louisiana
Sandy	65.0	2012	NJ/NY

(In nominal dollars from NOAA Billion Dollar data.)[70]

In addition to properly damage, at least 1,800 people died as a result of Hurricane Katrina. In addition, many residents had to leave the city, some permanently. The population of New Orleans fell by 29% between the fall of 2005 and 2011. Although many residents returned and the city's population increased to about 400,000 by 2020, it remained some 20% below its 2000 population.[71]

Other significant disruptions from the storm included loss of internet and phone connectivity, damage to the electric grid, and damage to hospitals. These caused chaotic and traumatic conditions, which carry significant mental health effects.

The aforementioned disruptions impacted lower-income families more than others. They were disproportionally hit by the physical and mental health effects of surviving the storm, attempting to find medical attention, being forced to relocate hundreds of miles away from home, and having children uprooted from schools and friends.

Heat impacts on health

Heat is a primary impact of climate change caused by the greenhouse effect that has been driven by fossil fuel usage.[72] There are many recent examples of extreme heat; for example, one of the most extreme was the 2021 heat dome in the Northwest with temperatures 30°F higher than normal highs, which killed hundreds and melted highways and train lines.[73] Heat is expected to continue to intensify in the future; this reality requires discussion and

70 "U.S. Billion-Dollar Weather and Climate Disasters"; NOAA National Centers for Environmental Information (NCEI); 2024.
71 "Hurricane Katrina—Aftermath"; Britannica; June 25, 2024.
72 Note that temperature-related health concerns and deaths come from both hot and cold climate events that disproportionately impact disadvantaged populations. This issue paper addresses only the heat impacts. "Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019: a three-stage modelling study"; *The Lancet—Planetary Health*; July 2021.
73 "2021 Northwest Heat Dome: Causes, Impacts and Future Outlook"; Climate Hubs; U.S. Department of Agriculture; undated.

planning for those most vulnerable, which is the focus of this section. While heat is causing problems for everyone, it has a disproportionate effect on the lower-income populations causing them more financial stress and health risks.

An individual's income level is a critical factor in adapting to heat. Lower-income families are most vulnerable because they may lack resources such as air conditioning (AC) and mobility to relocate to get relief, either temporarily or permanently, to combat the heat. They spend a disproportionate amount of income on home energy cost (about 8% versus about 2% for other households).[74] Lower-income families tend to live in locations that are more exposed to the impacts of climate change.[75] Federal subsidies for covering heat costs lag subsidies for other costs; for example, the federal Low Income Home Energy Assistance Program (LIHEAP) program, which provides energy bill subsidies for low-income households, currently spends only about 11% of the budget toward AC bills (most is dedicated to heating bills).[76]

Having AC is becoming a necessity for tolerating a warmer planet, but it is not being accessed equally in heat-exposed geographic areas. In metro areas, urban areas have less AC prevalence than in suburban areas, while more rural areas are somewhere in the middle. The greatest AC probability difference is on the West Coast, but more and more residents are getting AC. For example, in Seattle, the progression in the last six years went from 33% with AC to 53%, but still there is a discrepancy by income: 64% for higher income and 41% for lower incomes.[77] While much of the U.S. is at more than 90% with AC, the probability of having AC is inversely proportionate to the share of population that is black or Latino. Income is the biggest factor for AC prevalence. Low-AC-prevalence areas (20th percentile) are 11°F hotter than the highest (80th percentile) and up to 19°F hotter during the day in summer.[78] Having AC counters the heat and confers several other health benefits, such as better sleep, cleaner air (less allergies), reduced dehydration risk, better cognitive function, and parasite control.[79] A major challenge for the low-income individuals who have AC is having outdated units that cannot handle the more extreme heat, that may break down, cost too much to repair, and cost too much to run.

74 "Inequality in the availability of residential air conditioning across 115 US metropolitan areas"; PNAS Nexus; September 2022.
75 "Findings on Disproportionate Risks of Climate Change to Low Income Individuals"; op cit.
76 "Inequality in the availability of residential air conditioning across 115 US metropolitan areas"; op. cit.
77 "Seattle is no longer the least air-conditioned major metro area"; *The Seattle Times*; August 5, 2023.
78 "Inequality in the availability of residential air conditioning across 115 US metropolitan areas"; op. cit.
79 "Top 10 Benefits of Air Conditioning"; Brennan Heating & Air Conditioning; February 16, 2024.

Heat can also exacerbate employment issues as it can cause individuals in certain industries to reduce work hours thus creating financial hardship. Some workers are taking additional risk of heat exposure to try to maintain their income, thus risking their health, potential disability, and loss of life. Loss of income is about 5% for each hot day in poorer counties in the U.S. while it is less than 1% in other wealthy counties. A wide variety of workers are affected beyond agriculture: factories, warehouses, restaurants, airlines, telecom, delivery services, energy companies, and health aides all feel the effects. Heat hits non-agriculture sectors harder because they are more labor-intensive (heat events lead to more absenteeism and fewer work hours). In 2020 there was $100 billion loss of labor which is expected to grow to $500 billion per year by 2050.[80] When the temperature reaches 90 degrees, productivity drops by 25%; when it gets to 100 degrees, it drops by 70%; not only are there slowdowns but also more mistakes.[81]

The federal agency responsible for workplace safety, the Occupational Safety and Health Administration (OSHA), continues to refine its heat-related rules and to provide education efforts related to the impact of heat on workers.[82] A few states also have specific heat-related regulations.[83] But some states without specific heat-related regulations have heat-related impacts such as in Texas, where they have the worst loss in productivity.[84] Employers are working with federal and state entities to comply with regulatory frameworks, but compliance can be expensive and challenging for certain industries; small businesses installing air conditioners, where applicable, and reducing hours have helped, but as heat rises, so does the corresponding risk.

Water availability and quality impacts

Climate change has caused severe drought and flooding in some areas which has resulted in crisis in accessing drinking water. For example, the water crisis in the Colorado Basin is only forecast to guarantee current water usage through mid-2025, even given the better snowfall in 2023 and added conservation efforts.[85] The access to drinkable water issue is expected to grow in severity and geographically in the longer term, which makes a deeper look into water imperative. There are certain fundamental truths about drinking water. First, drinkable water is essential for health. A lack of drinkable water affects growth in children and exposes an individual to a variety of water-related diseases, such as diarrhea, cholera,

80 "Heat is Costing the US Economy Billions"; *The New York Times*; July 31, 2023.
81 Ibid.
82 "Department of Labor takes critical step in heat safety rulemaking, continues heightened enforcement efforts, focuses on dangers to agricultural workers"; OSHA National News Release; U.S. Department of Labor; May 8, 2024.
83 "Occupational Heat Safety Standards in the United States"; Natural Resources Defense Council; May 13, 2024.
84 "Heat is costing Texas & the U.S. billions of dollars, studies show"; *CBS News*; August 1, 2023.
85 *Management of the Colorado River: Water Allocations, Drought, and the Federal Role*; Congressional Research Service; April 4, 2024.

skin disorders, and infections such as hepatitis.[86] Hydration is critical in combating the increasing heat. But recent events have repeatedly demonstrated that the poor are much more vulnerable to climate impacts on access to drinking water.

Drinkable water access issues for the poor can vary depending on where the person lives. For urban dwellers, there is a pattern of poor water quality and high-risk exposure to climatic events. Towns and cities throughout the country, including those with high minority populations, have suffered from insufficient water systems and decades of underinvestment which can be particularly catastrophic when confronted with the more severe climatic events. One recent example is from Jackson, Miss., where a barely functioning water system was overwhelmed by a severe rain event. The city shifted from a chronic boil-water requirement before the storm to completely unusable tap water and reliance on bottled water for months.[87] Another example is seen in Las Vegas, N.M., where the outdated water system proved no match for the catastrophic wildfires that consumed the city's water shed. The city's filtration plant could not handle the murky water than came down from the burnt forests. A temporary filtration system has alleviated some of the immediate crisis, but a FEMA-funded new filtration plant won't be in place for up to six years.[88] Poorer water quality caused by climate change can result in exposure to toxins that can have ill effects. For example, high levels of lead causes cancer, heart/kidney problems, damage to immune/reproductive systems and alter brain function, and even contact with this water can cause eye/respiratory infections and hepatitis.[89] The resulting lead exposure is particularly harmful to children.[90] There are similarly situated municipalities across the U.S. where climate-driven water system catastrophes are waiting to happen.

Valley fever, a fungal fever associated with drought, is increasing in all drought-stricken parts of the Southwest. Estimates of the costs to the state of California are over $700 million per year, with a mild case costing about $25,000 and the most severe cases costing more than a million dollars.[91] The estimated economic impact of valley fever from the time period 2000–2015 was about $3.9 billion per year. [92] Persons who work outside are particularly vulnerable.

86 "What effects does water pollution have on human health?" *MedicalNewsToday*; November 23, 2020.
87 "Decades of systemic racism seen as root of Jackson Mississippi water crisis"; Associated Press, September 16, 2022.
88 "How New Mexico's Largest Wildfire Set Off a Drinking Water Crisis"; *The New York Times*, September 2, 2022.
89 *Report on the Environment—Drinking Water*; U.S. Environmental Protection Agency; July 8, 2024.
90 "Lead Exposure Symptoms and Complications"; Childhood Lead Poisoning Prevention; U.S. Centers for Disease Control and Prevention; April 10, 2024.
91 "The Rise of Valley Fever: Prevalence and Cost Burden of Coccidioidomycosis Infection in California"; *International Journal of Environmental Research and Public Health*; March 28, 2019.
92 Ibid.

Also, in municipalities, there can be water pricing during droughts that result in inequities—attempts by water providers to curtail water use by asking consumers to cut back on usage but adding surcharges to keep revenue to the providers consistent.[93] The result is not intuitive. Bills can rise for low-income households and drop for high-income households. High-income households can cut back use significantly, because they have discretionary use (e.g., large lawns to water) and may have lower bills than before the surcharge was applied. Lower-income households have much less discretionary use and end up with higher bills than before the surcharge was applied. Also, as a response to drought, water utilities may invest in expensive technologies which can increase the water bills to an unaffordable level.[94] A lack of affordability cuts water access.

For rural dwellers, there are various barriers to access to drinkable water. While national and state-level statistics may look good, there are concentrations of water problems throughout the country. In a recent study that looked at the combination of incomplete plumbing, poor quality drinking water and poor wastewater quality, there was evidence of regionally clustered, socially unequal crisis—for rural, poor, indigenous, lower-educated, and older people.[95] Drinking water safety issues are more widespread than we may expect. For example, 2.9% of counties have water system quality issues and 6.2% have violators that are polluting the waters, 153+ million people live in counties where there are some violators of clean water.[96]

Additional rural barriers to drinkable water include small water systems, competition from farms for underground water, and contamination from agricultural and oil/gas production operations. Rural areas are more isolated from bigger water systems and lack local resources to meet EPA regulations and make repairs or install water treatment plants. Many families rely on private wells that can be degraded by agriculture or other industries that can afford to drill even deeper wells. They can't afford the $7,000-15,000 costs to drill deeper wells and to get federal aid for wells requires a minimum of 15 service connections, which is not realistic in most cases.[97] So eventually, some families must rely upon water shipments and cuts to water usage like cooking, bathing, and washing clothes. In addition, as underground water levels drop, the quality of water drops and the risk of water contamination rises: thallium from oil/gas and industrial agriculture (attacks nervous system), arsenic (attacks many organs) and nitrates (causes blood disorders).[98]

93 "New Stanford research shows droughts can make water unaffordable for low-income households"; Stanford Report; January 19, 2023.
94 "Socio-hydrological Drought Impacts on Urban Water Affordability"; *Nature Water*; January 19, 2023.
95 "The widespread and unjust drinking water and clean water crisis in the United States"; *Nature Communications*; June 2021.
96 Ibid.
97 "Lessons on Climate Change and Poverty From the California Drought"; Center for American Progress; August 19, 2015.
98 *Report on the Environment—Drinking Water*; op. cit.

Agriculture uses 80% of the U.S. water resources.[99] This is a necessary and important use of the U.S. water resources. The complications that come from agricultural water usage are efficient irrigation systems and fair long-term access to water rights. In addition, some of the water running off from agricultural lands includes fertilizers that increase the growth of algae in some water systems with a resulting cycle of toxins and bacteria reducing the level of oxygen in the water.[100] Advances in farming techniques and changes to regulations may mitigate the difficult impacts of water availability.

Possible solutions

Introduction

Solutions discussed below include alternative state-based insurance solutions, parametric insurance, and increased emphasis on risk mitigation. These are not all of the possible solutions reducing the inequities and availability issues associated with climatic events, but illustrate several potential areas from which a discussion can start. Solutions such as microinsurance may also be an alternative as a starting point for protecting these disadvantaged populations.

State-based insurance solutions—Florida's Citizens Property Insurance Corporation

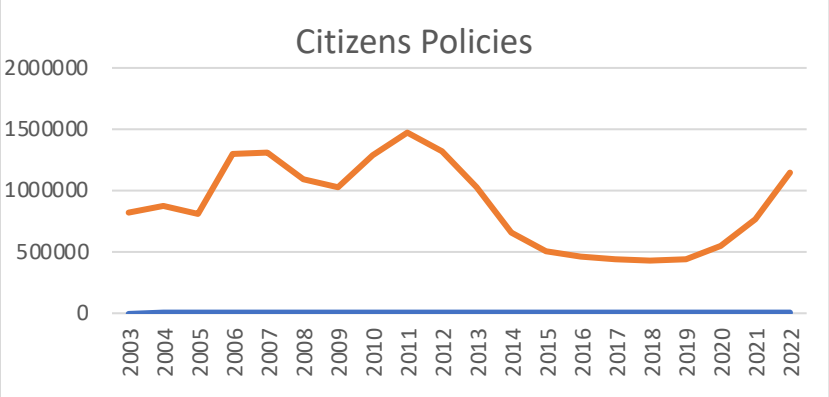
After claims from Hurricane Andrew in 1992, several insurance companies were bankrupted, while others stopped writing or renewing property insurance policies in the state. As a result of this market contraction, the Florida Legislature authorized the formation of the Florida Residential Property and Casualty Joint Underwriting Association and the Florida Windstorm Underwriting Association as the insurers of last resort. Ultimately, it merged them to create Citizens Property Insurance Corporation (Citizens), whose goal is to more efficiently and effectively provide insurance to, and serve the needs of, homeowners in high-risk areas and others who cannot find coverage in the open, private insurance market.

Since its inception, the need for Citizens' policies has fluctuated, depending on hurricane activity. After the four major Florida storms in 2004, followed by the 2005 storms, its policy count roughly doubled. Then, as the hurricane activity lessened, several insurers reentered the Florida property insurance market and the Citizen policy county dropped significantly. As of October 2019, Citizen's policy count had dropped to 419,000[101] but rose again due to a number of issues, including companies enacting stricter underwriting standards and a

99 "The widespread and unjust drinking water and clean water crisis in the United States"; op cit.
100 *Report on the Environment—Drinking Water*; op. cit.
101 Policies in Force; Citizens Property Insurance Corporation.

number of companies becoming insolvent following hurricanes Irma (2017) and Michael (2022). Citizens estimated that it insured 15% of the market by end of 2022.[102]

Citizens' rates are not generally considered actuarially sound and are below market levels in many parts of the state, due to the insurer's statutory glidepath that limits annual increases. But insurance industry leaders and Citizens' financial documents indicate that Citizens is far from becoming insolvent.[103]



Other states are using existing property markets of last resort originally designed for other purposes, including the Fair Access to Insurance Requirements (FAIR) plans. The California FAIR Plan or the Hawaii Property Insurance Association offer solutions to the increase in climate-related losses.

Significant concentration of insured properties, especially geographic concentrations, will always warrant vigilant monitoring. This is certainly the case when rates are not considered adequate and when pricing for volatile catastrophic events.[104]

Parametric insurance

What is parametric insurance and how does it differ from traditional insurance?

The NAIC Center for Policy Research defines parametric insurance as an indexed-based insurance where the amount of the payout is a set amount based on an objectively measured event of a specified magnitude and the payout is determined immediately after the disaster.[105] Triggers for disaster of parametric policies are correlated with actual losses that measure the intensity of an event. Benefit payments made under a parametric policy are directly tied to the intensity of an event.

102 "Exposure Reduction Committee Minutes"; Board of Governors; Citizens Property Insurance Corporation; March 29, 2023.
103 *Corporate Analytics Business Overview*; Citizens Property Insurance Corporation; December 31, 2022.
104 This paragraph was added in January 2025.
105 "Parametric Disaster Insurance"; National Association of Insurance Commissioners; undated.

Because parametric insurance depends on an objective trigger determined immediately after a disaster, it can provide financial risk protection against disasters by disbursing funds quickly to victims and improving financial resiliency to communities recovering from climate-related disasters. Additionally, overhead costs associated with loss adjustment are substantially less for parametric insurance than traditional insurance, making it cost-effective to issue smaller policy sizes.

In contrast, traditional property indemnity insurance provides protection for a loss, subject to deductible and claim limits, by reimbursing the policyholder for specific damages arising from a specified event restoring the asset to its pre-damaged state. The claim loss adjuster assesses the actual damage supporting the claim. For example, auto insurance will reimburse the actual cost of repairs and homeowners insurance pays the costs of fixing the damage. The insurance company utilizes a loss adjuster to assess the actual damage and payments cannot take place until the conclusion of a lengthy loss adjustment process is finalized. It may take several months from the date of claim notification until the time funds are received by the policyholder.

Parametric insurance can also be used to provide risk protection for new environmental risks which are not available through indemnity policies. For these policies, a policyholder has flexibility in determining how best to use policy proceeds.

What are the advantages of using parametric insurance versus traditional insurance?
Multiple locations throughout the world have utilized parametric insurance programs designed with lower premiums and adjusted benefits to improve financial resilience of lower-income population groups. One disadvantage with parametric insurance solutions is that the policyholder has "basis risk" because the benefit does not cover the full amount of the loss to the individual. The trade-off to the individual is the availability, affordability, and speed of remuneration of some form of financial protection compared with traditional insurance's high levels of protection that come with higher premiums and the longer time frame for claims administration.

Parametric insurance is easily modified to provide climate risk protection to individuals and business arising from natural disasters. The ability to receive funds within several weeks of the disaster provides needed liquidity to cover post-disaster recover expenses. The number of carriers and risk pools willing to assume risk is increasing, and currently includes at least half a dozen carriers that provide parametric insurance contracts.

Additional financing solutions

Additional areas for financing of the property losses associated with climatic events are sure to develop over time. An emerging area may include captive insurance.[106] Captive insurance has not been used for personal lines insurance due in part to regulatory barriers both in insurance regulations as well as in acceptance by mortgage holders. Captive insurers in most current statutes are not covered by insurance guaranty funds, which is an often-cited drawback. There are some thoughts about the potential for its use.

Environmental, social, and governance (ESG) investors may provide a source of equity or debt capital supporting the issuance of parametric insurance policies.

Risk mitigation practices

Property

By incorporating specific risk mitigation practices, a policyholder can reduce exposure to losses arising from flood, fire, and prolonged periods of cold weather and high wind events. The following are a few examples of specific ways that individuals can mitigate their risk of property loss:

- Raising the height of furnace and electrical panels within a basement by a number of inches/feet based on a location's flood protection level can help a homeowner avoid the impact that rising water levels may have on electric, heating, and air conditioning systems.[107]

- Extended periods of cold weather in winter may lead to frozen and broken water pipes, which may result in significant water damage to the home. The ability to remotely monitor room temperatures to ensure the heating system and room temperatures are set at proper levels may/can reduce this risk. In addition, insulation will protect pipes, more often in place in northern parts of the U.S.,[108] with the southern U.S. having less-well-protected pipes.

- FEMA recommends ASTM-rated shingles that meet the area's local code regulations and wind requirements or International Building Code requirements, whichever is stricter.

106 "Utah Captives Offer Solution to Homeowners Insurance Dilemma"; Captive.com; April 25, 2024.
107 "Protecting Building Utility Systems From Flood Damage"; Federal Emergency Management Agency; U.S. Department of Homeland Defense; February 2017.
108 "How to Prevent and Repair Frozen Pipes"; Lowe's; December 9, 2022.

- Clearing away trees and brush near homes can reduce the spread of wildfires.
- Communities can become more resilient to heat events by changing paving from asphalt to cool pavement alternatives, increasing trees and greenery, or modifying building methods.[109]

Health-related risk mitigation

Many Medicaid plans cover certain non-medical items intended to offset the costs of medical care due to disease exacerbation. Expanding the list of things covered to include items directly associated with the health-related impacts of a climate event could mitigate the impact on populations with fewer economic resources. Examples include air purifiers for dually eligible Medicare/Medicaid beneficiaries, utility credits to cover AC costs, and expanded home visit benefits by medical professionals when local cooling facilities have closed. Expanded access to telehealth and remote care is important for those who remain in an area with diminished access to care, as well as for those who relocate and need to maintain continuity of care with established providers.

Health infrastructure is a community resource, but maintaining viable care networks is important to health insurers. Planning for delivery system resilience during disaster and climate emergencies includes identifying vulnerable populations as well as fragile care delivery pathways and facilities, while projecting potential unexpected and increased utilization of certain services. Potential solutions and considerations for planning for disaster and climate emergencies include:

- identifying lists of members of the population who will need supplemental care such as emergency generators during power outages to maintain medical equipment,
- improving delivery system capabilities without creating excess capacity,
- identifying alternative delivery methods such as home visits or treatment vans for localized primary care until the situation stabilizes, and
- expanding county-based health departments to provide immediate care.

109 "Reduce Heat Island Risks"; U.S. Environmental Protection Agency; April 1, 2024.

Communities may seek to provide incentives for providers to rebuild rather than relocate. It is important to ensure that populations continue to have access to affordable health insurance in areas susceptible to climate emergencies.

To the extent that health plans, whether public or private, are expected to achieve target trends or performance guarantees by regulation or oversight, regulators may want to consider the financial impacts that disasters have on the plans who pay for care.

Moving forward

What can the actuarial profession do? Actuaries can inform policymakers of any revisions in expectations that climate-driven trends bring about and offer input to forecasts of economic viability in areas where trends occur, illustrating the impacts of mitigation and resilience efforts. For example, in areas of increased hurricane risk trends, actuaries could work with engineers to help illustrate the outcomes of varying levels of building standards, based on updated expectations of climate risk events. Actuaries can design future scenarios and quantify the associated costs to public programs and private insurance under those scenarios.

Insurance plays a critical role in creating "financial resilience" for communities suffering from disasters. Moving forward, communities may consider implementing actions centered around risk reduction, communication, disaster preparedness, and immediate access to liquidity and recovery, with an informed understanding of the impact such events have on the most vulnerable residents in the community. Raising broader awareness of the need to increase risk reduction and alternative forms of insurance capacity can help address the needs of communities to help pay for the cost of recovery from climate-related disasters.

As actuaries become more aware of not only the aggregate impacts of climatic events and climate change, but also the potentially inequitable impacts on disadvantaged populations, they are well placed to evaluate potential solutions that ultimately translate to improved financial protection for all households, including low-income ones. Actuaries will be able to provide this input to others such as FEMA, NOAA, capital markets, regulators, and community resources after first recognizing these impacts.