Enhancing Resilience

through Neighborhood-Scale Strategies

Urban Land Institute

About the Urban Land Institute

The Urban Land Institute is a global, member-driven organization comprising more than 45,000 real estate and urban development professionals dedicated to advancing the Institute's mission of shaping the future of the built environment for transformative impact in communities worldwide.

ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and Asia Pacific regions, with members in 80 countries.

More information is available at uli.org. Follow ULI on Twitter, Facebook, LinkedIn, and Instagram.

About the ULI Urban Resilience Program

ULI's Urban Resilience program is focused on how buildings, cities, and communities can be more resilient to the impacts of climate change and other environmental vulnerabilities. The program works with ULI members to provide technical assistance, advance knowledge through research, and catalyze the adoption of transformative practices for real estate and land use policy.

About the Resilient Land Use Cohort

This report is part of a larger series of resilience technical assistance and learning opportunities called the Resilient Land Use Cohort (RLUC). The RLUC is a network of ULI district councils, member experts, and community partners in seven cities working together to identify strategies to be more resilient in the face of climate change and other vulnerabilities, including floods, extreme storms, droughts, wildfires, and extreme heat, as well as the related social, environmental, and economic impacts.

The RLUC provides on-the-ground technical assistance through ULI's flagship technical assistance models—Advisory Services panels and technical assistance panels. These panels leverage ULI member expertise to advise on complex real estate and land use challenges related to climate resilience and to address planning, zoning, land use, development strategy, housing, and infrastructure. ULI's Urban Resilience program convenes the cohort regularly to learn from national best practices and to discuss peer cities' next steps for advancing resilience through land use policies and development strategies. Funding for this engagement and the cohort is provided by the ULI Foundation with support from JPMorgan Chase.

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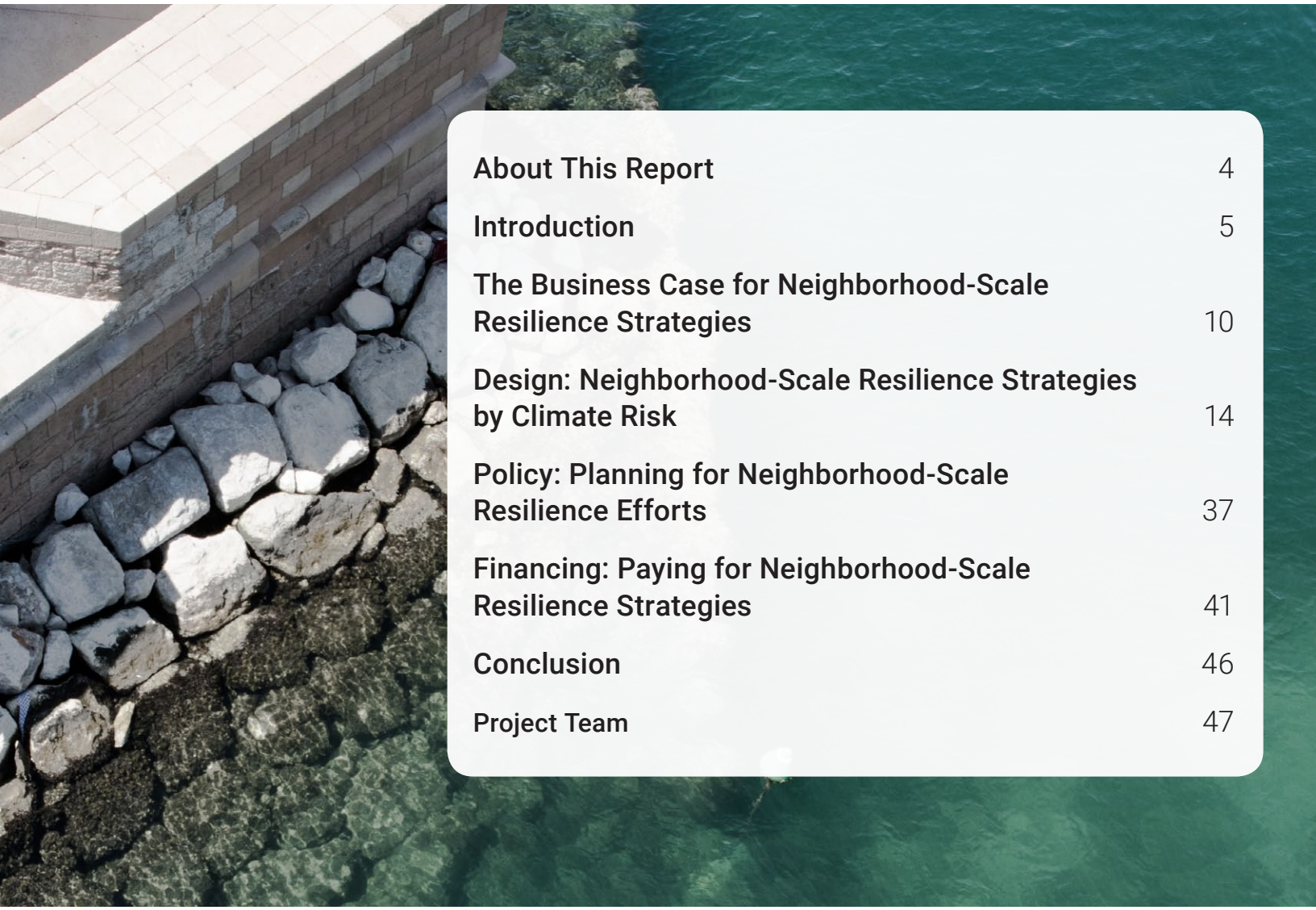


About This Report

Enhancing Resilience through Neighborhood-Scale Strategies introduces real estate actors, designers, policymakers, and finance professionals to the opportunities and challenges of preparing neighborhoods and communities for accelerating physical climate risks, including extreme temperatures, floods, storms and high winds, seismic risks, water stress and drought, and wildfires.

The report includes the following:

- The business case for neighborhood-scale resilience projects;
- A summary of several neighborhood-scale strategies for each physical climate risk;
- An overview of public-sector policies influencing the resilience strategy context; and
- A selection of financing solutions and funding mechanisms applicable to neighborhood-scale solutions.

As climate risks accelerate, many communities are facing new or intensifying risks. For every climate risk, however, hazard mitigation strategies exist that, if done at the neighborhood scale, can provide more collective protection than when they are done individually or ad hoc. Moreover, if planned and executed with equity in mind, neighborhood-scale strategies can account for higher-vulnerability individuals and groups, often low-income or Black, indigenous, and people of color (BIPOC) communities, which face historic and current structural barriers to adaptation and thus possess fewer resources to prepare for climate disruption.

Therefore, as communities develop neighborhood-scale strategies, social equity will need to be prioritized and community engagement will be an essential tool. As resilience design knowledge, supportive policy, and financing tools come into greater alignment, neighborhood-scale solutions can become mainstream practice and provide co-benefits for health and sustainability for current and future generations.

The report's key takeaways follow and are explored in further detail in the Introduction.

Key Takeaways

Design	Neighborhood-scale strategies exist for every hazard.
	Neighborhood resilience is critical because individual capacity varies.
Policy/Planning	Near-term actions and quick wins can jump-start resilience efforts.
	Community engagement is key to successful implementation.
	Social equity is a critical component of community resilience.
	Without a comprehensive approach, climate-friendly policy can be at odds with tax revenue.
Finance	Neighborhood-scale resilience strategies can have a strong business case.
	Co-benefits improve the business case for neighborhood-scale resilience projects.
	Financing and funding opportunities require expertise.

Introduction

As climate risks intensify, hazard mitigation strategies become focal points of neighborhood and community planning. This is especially true of high-risk areas, such as wildfire zones and floodplains. But with record droughts, floods, and rising sea levels, greater climate hazards are predicted in coming years, and more regions globally are experiencing climate shocks. Because of the wide reach and increasing frequency of such hazards, greater attention is being paid to the strategies that promote resilience at the neighborhood and community levels.

The need for neighborhood-scale resilience strategies is also an economic opportunity for communities to assess their risk, understand the hazards they face, and develop strategies that not only mitigate and respond to climate events but also create social and economic returns. Creating and implementing neighborhood-scale resilience strategies represents an opportunity to invest in communities and address hazards before catastrophe strikes. For those less-predictable climate events, such as earthquakes or a sudden rain event, efforts to promote resilience will better allow communities to respond and build back.

This publication introduces the basics of neighborhood-scale resilience strategies, categorized by hazard, with challenges and considerations relevant to each. It includes project profiles of where such efforts have been successful or innovative as well as policies and financing mechanisms to advance their use.

In addition to desktop research and interviews, this report draws on lessons learned from the Resilient Land Use Cohort (RLUC), a technical assistance and peer learning network managed by ULI's Urban Resilience program, which developed recommendations for neighborhood-scale resilience strategies in U.S. cities such as Chicago, Dallas, Philadelphia, and Tampa.

What Is a Neighborhood-Scale Resilience Strategy?

Both building-scale and neighborhood-scale strategies can contribute to the resilience of a community. Though action at both scales is important, ***this report focuses on the larger physical interventions conducted beyond the building scale***, including strategies and best practices to be more resilient in the face of floods, extreme storms, drought, wildfire, extreme heat, and the related social, environmental, and economic impacts.

For example, neighborhood-scale strategies might include coordinated tree planting, park or green corridor planning for flood protection, or the creation of firebreaks—solutions that are implemented over wider areas that are meant to protect the community as a whole.

Why Are Neighborhood-Scale Resilience Strategies Needed?

A building is only as resilient as its community. From utilities to roadways to public spaces, coordinated neighborhood-scale resilience strategies can provide protection to wide swaths of people and property. While building-scale strategies are an important complement, some hazards are better addressed through neighborhood strategies rather than building-specific measures, because exposure to physical risk changes from neighborhood to neighborhood, requiring changes to land use or infrastructure that individual property owners cannot implement.

There is also a growing business case to be made for investing in neighborhood-scale resilience

strategies. As discussed in the "Business Case for Neighborhood-Scale Resilience Strategies" section of this report, the real estate industry acknowledges the need for market-level resilience. Investors are developing approaches to better understand climate risk at the city or market scale and will increasingly incorporate more sophisticated analytics in deciding where to allocate capital, thereby affecting development in significant ways.

In addition, developers are beginning to articulate their interest in investing in a community that is building resilience at the neighborhood scale. As more measures are developed to quantify those interests and allow pricing to reflect those investments, demand is likely to increase. Neighborhood-specific strategies are particularly effective complements to shore up the limitations of individual, building-by-building or asset-scale improvements. With certain mitigation strategies, such as those for flooding, the neighborhood level presents greater opportunities to scale and coordinate efforts, leading to broader protection.

Finally, there is a case for social equity in climate adaptation and neighborhood resilience. In climate adaptation, the higher vulnerability and risk of damage from physical climate risks for vulnerable populations, including low-income or BIPOC households, the very young, the very old, and those with preexisting health conditions, is an issue of social equity. Effective policy includes ensuring that those who are directly affected by decision-making are included in the process of selecting and implementing neighborhood-scale resilience strategies.

"Boston's citywide heat resilience plan prioritizes social equity. The plan includes a focus on five neighborhoods that face disproportionate heat challenges due to environmental injustices, systemic racism, and planning histories. Community input and technical analysis together shaped the plan's recommendations for cooler neighborhoods and heat relief."

—Jill Allen Dixon, associate principal, Sasaki

Key Takeaways

Pursuing neighborhood-scale resilience strategies requires a complex set of considerations for design, policy, financing, and social equity and may require significant political will and community engagement to succeed. Following are several key takeaways for stakeholders across sectors to consider when embarking on the process.

Design

Neighborhood-scale strategies exist for every hazard. In addition to individual strategies and building-specific strategies, neighborhood-scale strategies exist for every hazard. Some climate hazards, like high-wind events and earthquakes, stand to have a greater benefit from building-scale interventions because both are hazards that exert significant lateral loads on buildings, and therefore

the risks posed by both are mitigated by a high-performing structural system and less related to neighborhood land use or infrastructure.

Neighborhood resilience is critical because individual capacity varies. Most resilience strategies are still voluntary, which means mitigation measures are deployed unevenly across a community. Neighborhood-scale resilience strategies can offer a baseline level of protection to a wider number of people and properties.

Unless carefully scaled up and coordinated, individual strategies may fall short of the community-wide planning needed for effective hazard mitigation, such as evacuation routes during a wildfire or flood, ingress and egress routes, access to fire stations, firebreaks or seawalls, or evacuation shelters for storms.

Policy and Planning

Near-term actions and quick wins can jump-start resilience efforts. Although many neighborhood-scale resilience strategies require time and collaboration, steps that can be taken in the short term can help improve outcomes. Such "quick wins" can include community engagement plans, communicating about emergency preparedness, and public education campaigns.

One challenge is the perceived lack of urgency for less common hazards (i.e., earthquakes) or in regions where a significant disaster has not occurred in recent memory. Short-term projects that produce quick wins can jump-start projects that require more momentum to sustain—and communicate the need for taking action.

Community engagement is key to successful implementation. One of the biggest hurdles neighborhood-scale resilience strategies face is the lack of political will for expensive projects or political disagreement in the face of major changes, such as relocation. An inclusive process and effective community engagement that accounts for the digital divide is often necessary for citywide change, and finding ways to align goals will help bring more groups to the table and prevent silos from forming. Research shows that trust in the community will also help more neighborhoods make better decisions in the face of uncertainty.

Social equity is a critical component of community resilience. Taking steps to make a community more resilient in the face of climate disasters also means strengthening social equity and building social capital, which measures the level of neighborhood interaction. This will allow a community to be more resilient in the face of a crisis. Where community interaction is lacking, vulnerable people remain more isolated.

> "Social equity becomes fundamental to a strong city. We can't have certain areas growing and certain ones under distress and separate the two."
>
> —Scott Goldstein, ULI Chicago

Without a comprehensive approach, climate-friendly policy can be at odds with tax revenue. Municipalities depend heavily on a growing tax base to fund city budgets. One reason localities still allow building along flood-prone waterfronts, the wildland-urban interface, or other areas subject to high climate risk, is the appeal of an expanded tax base, especially in areas of high real estate values. Policy that can create high-value areas in safer zones through tools like transfers of development rights can help offset these impacts. The policy section of this publication includes discussion of the challenges faced by zoning policies and policies that curb development, along with details on incentives and other ways in which to encourage development in lower-risk areas.

Finance

Neighborhood-scale resilience strategies can have a strong business case. Neighborhood-scale resilience strategies can create a strong business case, for example through preservation or enhancement of property value or greater marketability, and are becoming more attractive to investors and stakeholders throughout the real estate value chain. However, costs of resilience solutions vary, and infrastructure improvements require significant capital investment. Improving metrics that inform cost/benefit analysis will allow governments and investors to price the cost of not taking action and evaluate the returns of adaptation options, and may encourage more stakeholders to take action. This is discussed more fully in the "Business Case" section.

Co-benefits improve the business case for neighborhood-scale resilience projects. Neighborhood-scale resilience efforts are more likely to be successful if multiple benefits are associated with the project. Co-benefits can include positive health outcomes, community recreation space, green space, and more. Projects addressing climate change also must compete against other community priorities and limited public capital spending, especially after the budgetary effects of COVID-19. By highlighting the co-benefits available in neighborhood-scale resilience projects, advocates may create opportunities for funding and enhanced community support.

Financing and funding opportunities require expertise. As with any complex, multidisciplinary project, financing and funding mechanisms benefit from expertise and leadership—including skills in navigating federal grant-making and application processes. Larger municipalities may be in a better position to have dedicated staff to pursue such funding, but smaller municipalities still have a variety of options to raise capital for neighborhood-scale resilience projects. In particular, public/private partnerships are a way to expand city capacity and integrate additional expertise, particularly on acquiring financing and upfront capital.

In many European cities, tram tracks are lined with grass, reducing the urban heat island effect and providing a permeable surface to aid in stormwater management.

The Business Case for Neighborhood-Scale Resilience Strategies

Cities are challenged to develop and maintain the physical infrastructure needed to prepare for the impacts of climate change. Those that muster the fiscal resources—and political will—to mitigate their climate risks will be better positioned to thrive despite a warming climate. This section discusses how markets are beginning to change in anticipation of increased climate events, how implementing neighborhood-scale resilience strategies has the potential to spur economic growth, and the potential consequences of unaddressed climate risk.

"This is not a doomsday scenario for most cities, but stakeholders must agree to collaborate, innovate, and adapt. New urban design practices can facilitate sustainable urban investments in ways that also create new civic value and opportunities for equitable development."

—Uwe Brandes, professor of the practice, faculty director of the Georgetown Global Cities Initiative

Presenting a Compelling Business Case to the Private and Public Sectors

The benefits/cost ratio (BCR) of proactive neighborhood-scale resilience strategies has been analyzed by the National Institute of Building Sciences, which found that 12 federal Economic Development Administration grants with neighborhood-scale resilience strategies (elevating roads and railroads, protecting water and wastewater treatment plans, and moving power lines underground) that cost an overall $580 million to implement, were projected to save $2.5 billion in recovery costs such as loss of use.

Further, ULI's *The Business Case for Resilience in Southeast Florida* report outlines the returns from investments in resilience infrastructure in south Florida, where coastal property values may soon decrease because of climate change. For every $1 invested in community-wide adaptations, the region will see about $2 in benefits. These adaptations can offer $37.9 billion in economic benefits for the region and support 85,000 job-years (a job-year being defined as one year of work for one person). The BCR is even higher (4:1) for building-level adaptations.

The scale of savings outlined in these reports shows that many stand to benefit from resilience strategies. More public investment has the potential to lower exposure to climate risk, thereby reducing the likelihood of business interruption and lowering recovery costs for individual developers and private owners.

Facing the Costs of Inaction

Benefits may be even greater when the full cost of inaction is taken into consideration. It is far more effective to make investments proactively, rather than waiting for disaster to strike. For example, an analysis in Phoenix found that extreme heat costs the population $7.3 million each year in emergency room visits and hospitalizations and costs transportation agencies $100 million for fixing roads that buckle, crack, and rot.

However, a single mitigation measure, such as adding 25 percent more urban tree canopy, would yield $15 billion in benefits, almost four times as much as the cost. Furthermore, localities that do not take action on climate risk may face disinvestment in the future and risk a depleted tax base if and when a climate disaster strikes.

The industry as a whole is still developing metrics that measure and include the cost of climate risks across markets, but doing so will clarify the value of investments in adaptation for multiple stakeholders.

"When we did our first report, *Climate Risk and Real Estate Investment Decision-Making*, published in 2019, we were asking investors how much risk was in their portfolio related to climate. Half of the managers were just thinking about it and had not mapped their portfolio to climate risk. In the 2020 report, *Climate Risk and Real Estate: Emerging Practices for Market Assessment*, nearly all of them were. In our first report, investors were very reliant on insurance, which reprices on an annual basis for assessing climate risk. Now investors understand the need to model that risk over longer periods of time. Insurance can protect us against damage loss but not demographic or investor sentiment changes."

—Laura Craft, head of global strategy and investment ESG, Heitman

Enhancing Neighborhood Value and Marketability

As investors take an increased interest in proactive neighborhood-scale resilience strategies, markets that successfully implement risk mitigation techniques and differentiate themselves as safe investments can look toward enhanced neighborhood value and marketability compared to markets perceived as risky. This can, in turn, lead to higher sale or resale value and an increased property tax base.

Other community amenities can be integrated into the neighborhood-scale resilience measures and may further enhance marketability. For instance, thoughtfully designed green/blue spaces can not only store water and reduce flooding, but they can also serve as a park with features such as bike paths that may help attract new residents and improve livability.

Reducing Insurance Premiums

Insurance premiums are rising on properties across the board, not just in Florida or the coastal Carolinas. Increased insurance means increased costs to cities for city-owned buildings as well as private owners. Higher insurance costs may drive existing residents or developers out, reducing tax revenue as well as the incentive for new development. This can lead to loss of population and a reduced population gain—which further depletes the tax base of a community.

Implementing neighborhood-scale resilience strategies can lead to reduced insurance premiums. Programs like the Community Rating System (CRS) through the Federal Emergency Management Agency (FEMA) create a voluntary incentive program that rewards proactive floodplain management practices in more than 1,500 participating communities. In CRS communities, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community's efforts to avoid flood damage to property and foster comprehensive floodplain management.

Becoming More Attractive to Investors

Climate disasters are associated with high costs: insurance, building damage, recovery costs, lost revenue due to downtime, in addition to any human loss of life. Climate-conscious developers and

investors may be less likely to invest in buildings located in vulnerable areas of a city because of these higher costs. Climate risk is an essential data point for market or asset evaluation, and the lack of neighborhood-scale resilience strategies (as well as building-scale strategies) has the potential to spoil a deal.

Neighborhood-scale resilience strategies reduce vulnerability and therefore decrease costs of ownership in higher-risk areas. Some investors are becoming more interested in investing in communities that are aware of, and proactively mitigate, their climate risk to ensure their returns are protected long term.

"Investors often see climate risk as a 'tiebreaker issue' that makes a difference if other market-level concerns exist."

—*Climate Risk and Real Estate: Emerging Practices for Market Assessment*

Preserving Value, Marketability, and Access to Capital

Investors are already acknowledging that risks posed by climate events are material and will have an impact. Enacting neighborhood-scale resilience strategies can affect perceptions of how viable and stable a community or region is when facing physical climate risks. Rating companies like Moodys have said they will factor climate change into their sovereign ratings, which investors use to assess a bond's risk level.

A drop in a municipality's bond rating could lead to higher cost of capital, stifling development. Thoughtfully executed neighborhood-scale resilience strategies can have a positive impact as mitigation strategies are examined more closely when bond ratings are issued.

For more on climate migration and population change, read *Climate Migration and Real Estate Investment Decision-Making*

Avoiding Loss from Market Dislocation

Market dislocation is a huge concern for cities and is already associated with areas of land becoming uninhabitable. This can be seen in some locations with regard to floods, related population shifts, and subsequent bankruptcy in some parts of the coastal Carolinas and the demographic shifts created in New Orleans after much of the population displaced by Hurricane Katrina did not return following the storm, though this may be balanced by later in-migration. In California, wildfires are causing demographic shifts as people wonder where it is safe to rebuild.

Neighborhood-scale resilience strategies can mitigate risk before a catastrophe, reducing the potential for large-scale dislocation and business disruption. In the instances when a community is rebuilding after a climate event, incorporating resilient strategies into the recovery process can help ensure the population remains and the community prospers.

"These risks are real, and it's at your own peril that you ignore them. These risks will shape land values, and it is important to acknowledge and quantify them today."

—Uwe Brandes, professor of the practice, faculty director of the Georgetown Global Cities Initiative

Design: Neighborhood-Scale Resilience Strategies by Climate Risk

Communities can use a wide variety of neighborhood-scale resilience strategies to prepare for the effects of climate change, and more innovations are constantly being made. Many of these strategies serve as complements to building-scale resilience strategies, as discussed in ULI's companion report, *Resilient Retrofits: Climate Upgrades for Existing Buildings*.

This section introduces a selection of strategies that city planners, developers, and architecture, engineering, and construction professionals can explore to increase resilience to **extreme temperatures**, **floods**, **seismic risks**, **storms and high winds**, **water stress and drought**, and **wildfires**. Many of these techniques have overlapping co-benefits and tradeoffs, and each section includes challenges and considerations to be evaluated.

"It's not just rising sea level. Communities also have issues with heat island effect, air and noise pollution from highways, financial limitations, etc., and these more day-to-day environmental and health-related shocks and stressors can disproportionately impact minority communities."

—Taylor Ralph, REAL Building Consultants, Tampa

For more examples of resilient strategies, explore ULI's library of project profiles, *Developing Urban Resilience*.

Assessing Risk and Vulnerability

The first step to implementing neighborhood-scale resilience strategies is understanding the community's potential levels of exposure and vulnerability to physical risks. Community mapping to understand the landscape of climate risks is valuable both in long-term planning and to secure community buy-in for hazard mitigation strategies.

Some communities, such as New York City and Boston, have begun to develop city-specific projections for future climate risks such as flooding or extreme heat under varying scenarios that can be used to inform planning, and many cities have developed climate resilience plans highlighting which neighborhoods are especially at risk and what will be done to protect residents.

In addition, tools such as FEMA's National Risk Index or the U.S. Climate Resilience Toolkit's Steps to Resilience can guide the planning process for communities newer to the resilience planning process. When assessing risk and vulnerability, environmental, social, and economic factors must all be evaluated to produce a full picture of community risks and opportunities.

Extreme Temperatures

Heat is the deadliest weather-related hazard in the United States, and the frequency, intensity, and duration of heat waves are increasing across the globe. Climate change, primarily caused by greenhouse gas emissions, is increasing global average temperatures. The urban heat island effect—where cities trap heat, causing consequent temperature increase—means that urban areas are at an additional risk of major heat events.

Communities that have experience with extreme heat are seeking additional mitigation measures and increasing their response efforts during heat waves and higher average temperatures. Those communities that have not previously dealt with extreme heat, such as in the Pacific Northwest, are finding the need to quickly implement measures to better respond to such events. Extreme heat is known for its health impacts, but it can also damage infrastructure: when the Pacific Northwest experienced a historic heat dome event in 2021, the heat grew so intense that the rubber lining on trolley cables began melting, expediting the need for mitigation measures.

Heat also reduces economic productivity, increases energy and water use, strains infrastructure and ecosystems, and affects quality of life. The increased awareness of heat risk and the high need for mitigation mean that more cities and localities are creating specialized departments or roles to tackle the issue. Phoenix became the first city in the country to establish a department focused on heat response and mitigation. Other locations have created dedicated roles for climate resilience and heat mitigation, such as in Miami, where the first-ever chief heat officer position was created. These are strong examples of the new approach to "heat governance" that some experts are calling for.

> "The least-used strategies that communities are doing are regulating development and having staff that are tasked with addressing heat. A local community's strongest tool in [its] toolbox to deal with heat is zoning and land use regulations. Very few [communities] are using it, and it's a missed opportunity."
>
> —Ladd Keith, assistant professor of planning and sustainable built environments, chair of Sustainable Built Environments, University of Arizona

A selection of neighborhood-scale strategies to build resilience to extreme temperatures is listed in table 1; the following resources have more information:

- *Cool Neighborhoods NYC*, Developing Urban Resilience
- *Turning the Heat*, Urban Design Forum
- *Scorched: Extreme Heat and Real Estate*, ULI

Parks with ample green space and trees, or access to water, reduce the ambient temperature within the park and the surrounding neighborhood.

Table 1. Neighborhood-Scale Resilience Strategies for Extreme Temperatures

Urban forestry and increased vegetation	Improving tree canopy lowers the temperature in urban heat islands. Trees can be planted on public rights-of-way. When applied across neighborhoods, landscape design standards or landscape maintenance agreements between local governments and developers for installation and maintenance of newly planted trees or other landscaping during new construction can help preserve and expand canopy and other vegetation on private development. In addition, parks with ample green space and trees, or access to water, reduce the ambient temperature within the park and the surrounding neighborhood. In cities with little available space, underused spaces currently dedicated to cars can be converted to green space, as discussed in ULI's *Pavement to Parks* report. **Co-benefits and tradeoffs: Increased tree canopy and vegetation also help absorb stormwater and slow runoff, reducing flooding impacts while improving air quality and sequestering carbon. Increased vegetation, such as shade trees, can also reduce electricity demand by reducing cooling needs, which helps improve the reliability of the electrical grid, particularly during heat waves.**
Roadway diets and parking lot adjustments	Parking lots and roadways serve as major heat islands in cities by absorbing heat in paving materials and releasing it at night. Road diets, which replace traffic lanes with alternate designs such as expanded bike lanes or vegetated medians after road capacity and demand are evaluated, can reduce pavement and make room for additional green infrastructure. Municipalities can also update zoning codes and regulations to incentivize smaller parking lots or reduce parking minimums. Some cities have eliminated parking minimums or have enacted parking maximums as a complement to increasing bicycling and transit options. **Co-benefits and tradeoffs: Roadway diets and parking lot reductions not only create more opportunity for green space that reduces the urban heat island and increases space for green infrastructure that can reduce flooding, but also may incentivize the use of alternative transportation. With fewer cars on the road, greenhouse gas emissions and waste heat that contribute to the urban heat island are both reduced.**
Cool pavement treatments	Cool pavement treatments reflect more solar energy and evaporate less water than traditional materials. These treatments can be applied to public roadways and parking lots to cool urban areas. Hot-weather cities such as Los Angeles, Phoenix, Tempe, and Tucson are currently piloting different types of cool pavement treatments. They noted that cool pavement treatments on highly used surfaces like sidewalks may reflect heat back onto pedestrians. Now adaptations are being made to develop reflective surfaces that act more like "road sunscreen" to reduce heat absorption and less like a "reflective paint" that redirects solar radiation indiscriminately.

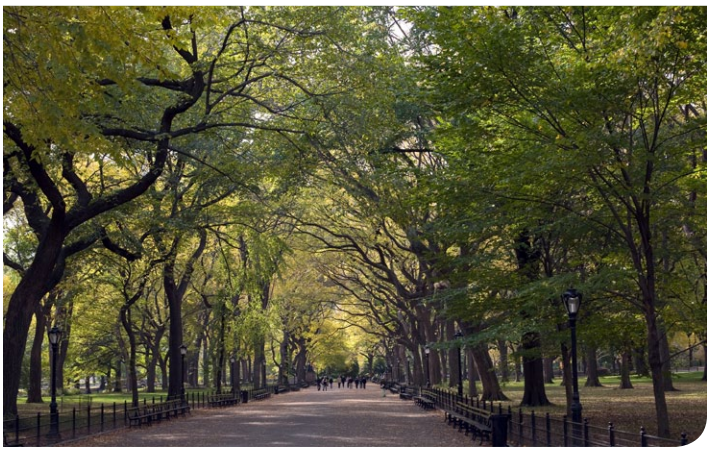
Table 1. Neighborhood-Scale Resilience Strategies for Extreme Temperatures continued	
Heat-resistant materials	Heat-resistant materials (e.g., ceramic, stainless steel) can be used in public infrastructure projects to better withstand extreme heat impacts.
Community cooling centers	Providing community cooling centers, particularly in areas with low-income, elderly, and young populations—who are most at risk for heat exposure—can be an effective strategy for heat management. Robust communication is needed both on location and access to community cooling centers, and coordination with community leaders on how to reach vulnerable populations who may not know to access them can increase the use and effectiveness of cooling centers. "Be a buddy programs" where neighbors check on neighbors during heat events can help build social cohesion by reaching isolated individuals and ensure those who may need help reaching cooling centers receive assistance.

Challenges and Considerations

Chronic heat can be just as dangerous as extreme heat. Decision-makers, public health officials, and emergency management personnel sometimes focus on extreme heat events, such as heat waves; however, progress is also needed on chronic heat, because higher average temperatures also contribute to higher mortality but may receive less attention than extreme heat waves. Addressing the social determinants of health, including housing, housing inequality, and access to health care, will save additional lives, as these factors play significant roles in heat exposure and coping ability.

Socially marginalized communities need additional consideration. The neighborhoods that stand to benefit most from heat resilience strategies are often those that have experienced longstanding systemic inequalities. For example, historic redlining policies and planning decisions have meant that lower-income communities and communities of color have not received the same level of public investment in trees and parks as neighborhoods that tend to be wealthier and whiter.

A spray park in Poland cools visitors on a hot day. Spray parks use significantly less water than municipal swimming pools and are more cost-effective to build.



Improving tree canopy lowers the temperature in urban heat islands.

Project Profile

Eco Smart City, Tengah, Singapore

Singapore is building a 42,000-home eco "smart" city. Tengah is designed for residents to be "at home with nature" while reducing air-conditioning emissions, decreasing vehicle emissions, and increasing the tree canopy to build resilience to extreme heat. It will consist of five residential districts on a 700-hectare (1,700 acre) site in Singapore's Western region, built on land once home to a brick works and later used for military training.

Tengah will include abundant green space, including a 100-meter-wide (330 ft) forest corridor that runs through the center of the town to connect a nature reserve and water catchment area and reduce the urban heat island effect. Two of the largest drivers of urban heat island effects are excessive use of asphalt for roads and parking, and excessive waste heat from vehicles themselves. To address this issue, vehicles in Tengah will run underground, simultaneously making the town center safer for walking, cycling, and recreational activities. This strategy also offers co-benefits for carbon mitigation: according to the town's energy provider, SP Group, this will generate carbon dioxide savings equivalent to taking 4,500 cars off the roads each year.

A challenge in hot climates is addressing the need for air conditioning without increasing greenhouse gas emissions. In Tengah, the units will be cooled using cold water, chilled using solar power, and piped through the building. This avoids the need to install outdoor air-conditioning condensers, reducing emissions while still providing residents the ability to control the temperature in their units.

To reduce the urban heat island effects and excessive waste heat, vehicles in Tengah will run underground, simultaneously making the town center safer for walking, cycling, and recreational activities. *(Courtesy of the Housing & Development Board)*

Tengah will include abundant green space, including a 100-meter-wide (330 ft) forest corridor that runs through the center of the town to connect a nature reserve and water catchment area and reduce the urban heat island effect. *(Courtesy of the Housing & Development Board)*

Floods

Sea levels in the United States are expected to rise by one foot by 2050, and moderate or damaging coastal floods are likely to occur 10 times as often as they do now. But floods are not just a coastal issue, inland flooding is a rising risk for communities far from the shore. These events bring a high cost: the extreme rainfall and subsequent flooding that plagued western Germany, Belgium, and the Netherlands in summer 2021 killed more than 220 people and, according to insurance companies, was "the costliest natural disaster Europe has ever seen."

Although efforts can be taken to protect individual homes and land parcels from flood events, the connected infrastructure of a community and the wide-ranging scope of projects needed for drastic mitigation require more neighborhood- and community-scale resilience strategies. Table 2 includes example strategies that can be followed at the neighborhood level to mitigate flooding. The following resources include additional information:

- *Green Infrastructure Toolkit*, Georgetown Climate Center
- *Building Community Resilience with Nature-Based Solutions*, FEMA
- Climate Ready Boston, city of Boston

Østervold, a green/blue urban space in Randers, Denmark, includes a rainwater basin to protect the city from the impacts of heavy rainstorms.

Table 2: Neighborhood-Scale Strategies for Flood Resilience

Green infrastructure	Integrating green infrastructure means adding green, vegetative, absorbent surfaces to replace impervious materials like concrete or asphalt. These surfaces act as a sponge, absorbing water. Green infrastructure can also include retention or detention spaces, where water can collect and then slowly drain without flooding homes and roads. These spaces can be combined with amenities like parks or sports fields that enhance a community's livability. Green routes can also act as water collection areas that double as walking or bicycling paths for the community. While green infrastructure is a popular and manageable strategy, it needs to be done at a large scale to make a significant difference during a major flood. This can be achieved by working with multiple property owners in a flood-prone area or by implementing larger solutions, such as greenways or flood retention areas in parks, rights-of-way, or other similarly sized tracts of land.
Wetland restoration	Wetland buffers are marshy areas that surround a body of water and are able to absorb excess water and wave energy during storm events to help protect surrounding communities. Many communities have allowed wetlands to be drained and developed and/or used for farming, but that land remains vulnerable to flooding. By restoring wetland buffers, the land can be used to contain floodwater and provide additional benefits such as biodiverse habitat and carbon sequestration.
Road raising	Road raising, where roads or rights-of-way are elevated above the flood level to decrease the risk of flooding, can be an effective way to preserve access in and out of a community during periodic or chronic flooding. Miami Beach is a prominent example of road raising, in which some roads were raised by two feet to combat rising sea levels. **Co-benefits and tradeoffs: Harmonizing higher roads with private property which would then reside below street level can present difficulties. Issues of accessibility and accommodation are something to be mindful of, as well as urban design considerations within the overall landscape of the existing roadway.**
Seawall	A seawall is a coastal structure built to prevent water from penetrating inland; it draws a line between an area that is designed to be wet and one designed to be dry. Many historic seawalls, such as the picturesque stone walls that run along the New England coast, have long served this important purpose, but they may not remain functional at their existing heights, as the sea level continues to rise. **Co-benefits and tradeoffs: Seawalls can block views of the water, which residents often value. Seawalls also may unintentionally redirect water to other locations lacking similar protection, simply relocating flood damage. In addition, they can cause ecological damage by cutting off ecosystem processes that require connections between inland and marine environments, such as near river deltas. One example of a more ecologically minded wall is the Seattle Seawall, which improved the migratory path for young salmon.**

Table 2: Neighborhood-Scale Strategies for Flood Resilience continued

Berm	A berm is a mound of earth, gravel, rock, or other material, usually linear, constructed to protect an area from flooding. It can be a bit softer than a seawall, potentially allowing residents of the area to maintain their water view and coexisting more easily with local ecology than a seawall. **Co-benefits and tradeoffs: Public amenities can be integrated into berms. For example, the sloping area can be a community amphitheater. The berm can also be part of a park, providing additional flood mitigation without negatively affecting the surrounding landscape, and may be integrated with walking or bike trails.**
Living shorelines	Living shorelines help protect coastlines from erosion and reduce storm surge by preserving, creating, or enhancing natural systems such as marshes, beaches, and dunes. According to Architecture 2030's 2030 Palette, living shorelines can be created by planting riparian, marsh, and submerged aquatic vegetation; installing organic materials such as bio-logs and organic fiber mats; managing, restoring, enhancing or creating new wetlands, coral reefs, and habitats; and constructing oyster reefs or "living breakwaters" that dissipate wave energy before reaching the shore.
Restoration of river edges	Rivers in urban areas have sometimes historically been channelized into concrete canals, ostensibly to reduce flood risk, a practice now viewed as counterproductive. Municipalities can consider removing constructed hard edges and expanding green space along waterways that can accommodate natural ebbs and flows, serving as additional flood control. Rivers completely covered over underground can also be "daylit" for similar purposes.

Challenges and Considerations

Scale of community change. Adding green infrastructure throughout a neighborhood is a significant visual change, to be sure, and migration strategies are more impactful still. Managed retreat or property buyouts are costly and disruptive and will require significant community buy-in and political will in addition to changing understandings in public expectations for climate disasters. For example, floods that once happened infrequently may now happen several years in a row, as seen in places like Houston and other locations around the country. Given projected impacts of the intensity and duration of storms, and local residents' expectations of risk, preparedness and the implications of various adaptation options may need to shift as well.

Changing data availability. In the United States, FEMA flood maps in many locations have not reflected changing flood trends caused by climate risk, requiring several years to be approved and being subject to political dynamics. Climate risk assessment providers are trying to close the gap as investor and municipal interest in real-time data metrics and solutions continues to increase.

Singapore's Bishan-Ang Mo Kio Park is a floodable park that protects the city from the waters of the Kallang River. The design includes water purification and recreational and educational opportunities as co-benefits.

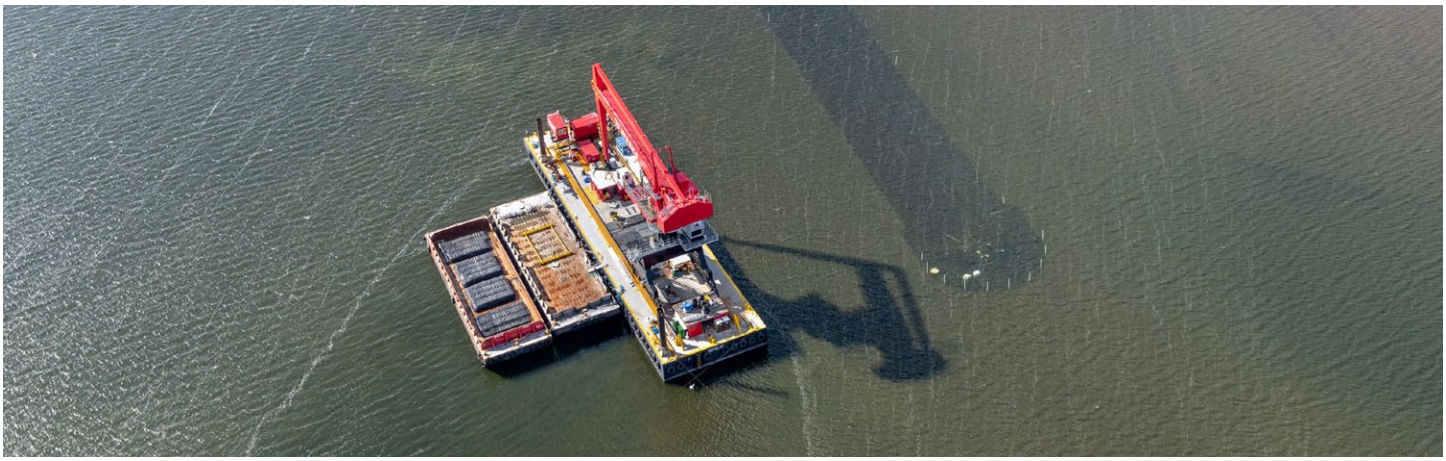
Project Profiles

Living Breakwaters, Staten Island, New York

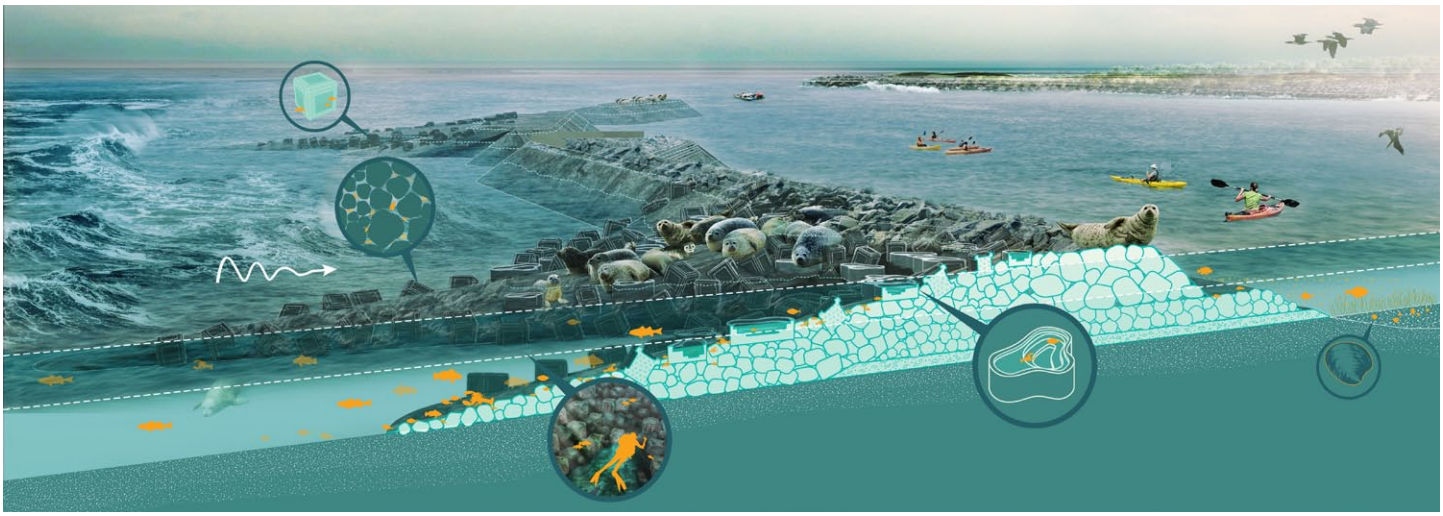
Living Breakwaters is a $107 million project designed by SCAPE for flood and storm mitigation for the coastal town of Tottenville, along the South Shore of Staten Island. This area experienced significant damage during Superstorm Sandy and needs a mitigation measure for expected future storms and rising sea levels.

The project creates 2,400 linear feet of breakwaters, which are partially submerged structures built near the shore out of stone and ecologically enhanced concrete units. These are designed to break waves and reduce erosion along the beach. These specific breakwaters will also be designed with "reef ridges" and "reef streets," which provide a suitable habitat for marine life.

The project also includes the goal of building social resilience in Tottenville with educational programming for local schools in partnership with the Billion Oyster Project and an open-access Living Breakwaters Curriculum.



The partially submerged structures are built of stone and ecologically enhanced concrete units. *(Weeks Marine Inc./Bernstein Associates, Courtesy SCAPE)*



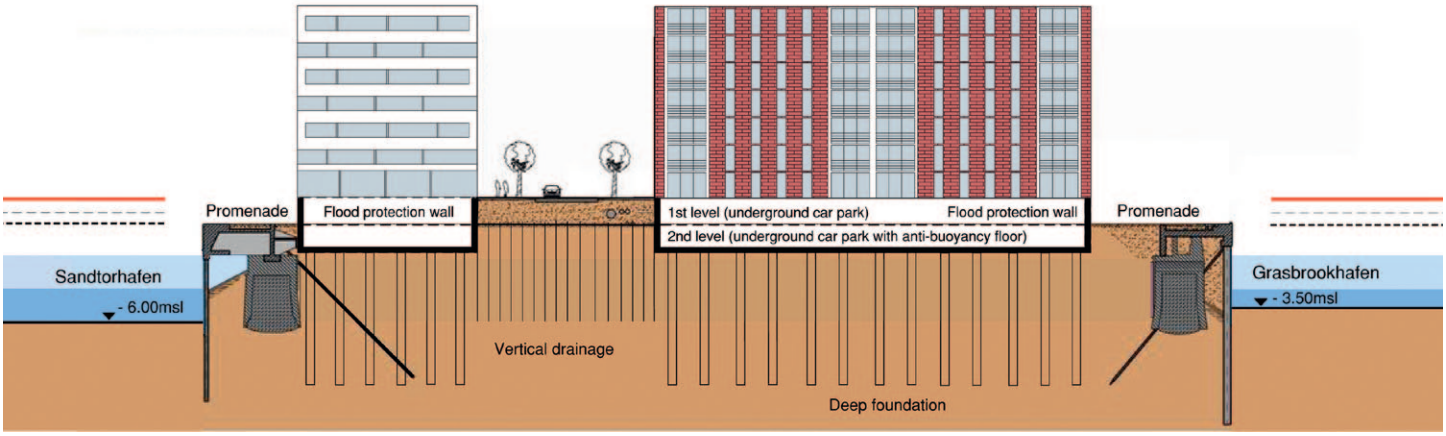
Living Breakwaters includes 2,400 linear feet of partially submerged structures designed to break waves and reduce erosion along Tottenville's beach as well as provide a suitable habitat for marine life. (SCAPE and the Living Breakwaters Team)

HafenCity, Hamburg, Germany

Hafencity is Europe's largest inner-city development project, enlarging the city center by 40 percent. This former port and industrial site is on a low-lying island that is prone to flooding.

Instead of raising the entire city by eight to nine meters (26 to 30 ft), which would be costly and difficult, HafenCity mitigates its flood risk by creating two tiers of raised structures, relying on the existing foundation when possible. The first set of elevated foundations consists of low-lying promenades, 4.5 meters (15 ft) above sea level. The second raised structures are the higher *warfts* (dwelling mounds, eight to nine meters [26 to 29 ft] above mean sea level). When possible, the historic quay's structural walls were conserved and restored. When needed, new walls were built.

The boundary between water and land is flexible and can be adjusted during floods and storm surges. This is achieved by having the promenades low lying and flood prone, but equipping the building plinths and entrances to parking garages with moveable flood gates. During storm surges, this allows for partial flooding without damage to buildings or cars. Incorporating such flexibility allows for more effective flood mitigation at a lower cost.



Instead of raising the entire city by eight to nine meters (26 to 30 ft), HafenCity mitigates its flood risk by creating two tiers of raised structures. *(HafenCity Hamburg GmbH)*

A former port and industrial site, Hamburg's HafenCity is located in the River Elbe and is prone to flooding. *(HafenCity Hamburg GmbH)*

Seismic Risk/Earthquakes

Earthquakes, unlike some other hazard events, strike without warning, and there are misconceptions about how to prepare and respond to one. In a place like the Pacific Northwest, with a wide coastline, the threat of earthquake is magnified by the impending tsunami wave that will likely follow. High-profile global tsunamis, such as the 2004 Boxing Day Tsunami in the Indian Ocean, which followed the Sumatra–Andaman earthquake, have shown the risk of unprecedented devastation and fatalities. Other cascading effects following an earthquake may include landslides, fires, infrastructure failure, and power outages.

While much effort is rightly focused on updating building codes in preparation for an earthquake, broader neighborhood-scale resilient strategies can also help mitigate earthquake risk, including preparing for the possibility of a tsunami, landslide, or power outage.

A selection of neighborhood-scale resilience strategies are listed in table 3; the following resources have more information.

- *Oregon Resilience Plan*, Oregon Seismic Safety Policy Advisory Commission
- REDi Rating System, Arup

"Safe Enough to Stay"

Building-scale seismic resilience is critical to community readiness. Retrofitting or designing for earthquake risk now can help ensure that during a major earthquake, residents can safely shelter in place while their own homes are undergoing repairs. This will lessen the need for community-wide shelters that often disrupt other community functions such as education (when schools are used as ad hoc shelters), help avoid a slow and arduous recovery, and create less disruption and chaos for residents immediately following a catastrophe. More information on the detailed housing recommendations from the Shelter in Place Task Force can be found in the *Safe Enough to Stay* report.

Evacuation routes must be clearly labeled—such as blue lines (representing a tsunami) with arrows pointing residents away from the coast and toward higher ground or evacuation-safe buildings that are clearly identified.

Critical transportation infrastructure, such as bridges, may need to be retrofitted to withstand the shock of an earthquake or the damage of a tsunami to ensure continued access to otherwise isolated communities.

Table 3: Neighborhood-Scale Strategies for Seismic/Earthquake Resilience	
Evacuation routes	Evacuation routes must be clearly labeled—such as blue lines (representing a tsunami) with arrows pointing residents away from the coast and toward higher ground or evacuation-safe buildings that are clearly identified. **Co-benefits and tradeoffs: Evacuation routes may be implemented for other hazard risks, including flood, hurricane, and wildfire.**
Community shelters	Schools, community centers, or other neighborhood amenities that are located outside of tsunami inundation zones and hardened to resist the forces of an earthquake can serve as evacuation centers and community shelters after a seismic event. Shelters are particularly necessary in areas with low-income, elderly, and young populations or in areas with older structures that are likely to suffer extensive damage during an earthquake. Robust communication is needed both on location and access to shelters, and coordination with community leaders on how to reach vulnerable populations and ensure shelters are accessible.
Strengthen transportation infrastructure	Critical transportation infrastructure, such as bridges, may need to be retrofitted to withstand the shock of an earthquake or the damage of a tsunami to ensure continued access to otherwise isolated communities.

Considerations and Challenges

Disaster amnesia. Generating enough political will to take preventive action is a challenge. In Oregon, researchers can pinpoint the last major earthquake to January 26, 1700. This specificity is owing to Japanese researchers who have kept detailed tsunami records for centuries. Even though it has been 300 years, another earthquake could strike without warning, and being prepared will save lives, improve outcomes, and lead to better and quicker rebuilding. It took an earthquake in Salt Lake City in 2020 for those surrounding municipalities to begin preparing for a bigger one and examine the seismically vulnerable places in need of improved resilience.

The power of narrative and storytelling. In examining the fatalities in the coastal regions hard hit by the 2004 Indian Ocean tsunami, some Indian Ocean islanders close to the epicenter survived by going to higher ground, knowing to do so because of folklore tales from 1907 about an earthquake and subsequent tsunami. Much of the neighborhood-scale resilience mitigation strategies focus on communicating clear preparedness and subsequent action for an earthquake; doing so in a way that incorporates this information into story or narrative form may have a longer-lasting impact. Even in the Paradise, California, wildfire, residents who better understood the scale of the damage and the need to evacuate fared better than those who were indecisive or unsure.

Community cohesion. The role of empowering communities, discussed in the Portland Earthquake Resilience plan, is pivotal in ensuring that critical needs can be met after a major earthquake. Communication infrastructure and proper planning are needed, but so is programming that strengthens social connections and links diverse organizations that may provide support and recovery services.

Project Profile

Shoalwater Bay Indian Tribe Tsunami Evacuation Tower, Tokeland, Washington

The Cascadia Subduction Zone runs along the Washington and Oregon coastlines. This intersection of two tectonic plates means the region is at increased risk for earthquakes and subsequent tsunamis. Earthquakes in the region are not frequent, but history shows they can occur and have potential devastating effects. The area is near the offshore fault line and has high risks of a tsunami, with only 22 minutes warning time following a Cascadia Subduction Zone earthquake, which does not allow for safe evacuation to reach high ground before a tsunami wave would reach the shore.

The Shoalwater Bay Indian tribe set out to build a vertical evacuation structure so that residents would be able to flee to safety. The 400-resident, 43-foot tower was under construction in spring 2022 with a targeted completion date later in the year. The tower is constructed to withstand both earthquake shaking and tsunami waves, and it will be made available to both tribal members and nontribal residents. It was funded through a $2.8 million grant from FEMA Pre-Disaster Mitigation and matched by tribal funds. This is the first tsunami evacuation tower of its kind in the country.

A 400-person, 43-foot vertical evacuation structure is being built by the Shoalwater Bay Indian Tribe, with support from FEMA, to ensure residents can safely escape an earthquake-induced tsunami. *(©2022 Rice Fergus Miller VizLab)*

Storms and High-Wind Events

High wind, whether from hurricanes, thunderstorms, tornadoes, or other storms can cause billions of dollars of damage to communities. In the United States, tornadoes are becoming more frequent, more intense, and more likely to come in swarms. Of similar alarm, new research finds that hurricane wind speeds are able to persist for longer durations after landfall, allowing high-wind conditions to travel farther inland. These trends mean strategies for high-wind resilience may be applicable to a wider variety of locations.

A selection of neighborhood-scale resilience strategies is listed in table 4, and the following resource has more information.

- *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*, FEMA

Aboveground utility wires are more likely to be damaged by climate disasters, like storms and high-wind events.

Table 4. Neighborhood-Scale Resilience Strategies for Storms and High-Wind Events	
Community shelters	Because tornadoes scan strike quickly with a short warning period of only 15 to 18 minutes on average, it is crucial to have tornado shelter options in schools, nursing homes, and institutions. Community shelters may also be necessary, particularly in areas near open space, such as fairgrounds or recreation fields. **Co-benefits and tradeoffs: If community shelters are located outside the floodplain, they can be used for both hurricanes and tornadoes.**
Tornado sirens and storm warnings	Notification systems are critical to warning residents of an impending high-wind event. Adding electronic/digital notifications in addition to sirens can facilitate greater reach.
Wind buffers and site design	In high-wind areas, damage associated with severe wind events can be reduced through use of wind buffers, such as trees and hedges. In addition, planned communities can minimize wind impacts by angling streets away from the prevailing wind direction, as was done in Arverne by the Sea.
Power lines and infrastructure maintenance	Wind damage can be reduced through routine maintenance of utility infrastructure. FEMA identifies strategies such as • Establishing standards for all utilities regarding tree pruning around lines; • Incorporating inspection and management of hazardous trees into the drainage system maintenance process; • Preemptively testing power line holes to determine if they are rotting; • Inspecting utility poles to ensure they meet specifications and are wind resistant; • Burying power lines to provide uninterrupted power after severe winds, considering both maintenance and repair issues; • Upgrading overhead utility lines (e.g., adjust utility pole heights, utility pole span widths, and/or line strength); • Avoiding use of aerial extensions to water, sewer, and gas lines; • Using designed-failure mode for power line design to allow lines to fall or fail in small sections rather than as a complete system to enable faster restoration; and • Installing redundancies and loop feeds.

Challenges and Considerations

Effective communication. Communication about impending storms is essential, especially during off-peak seasons and at night. The December 2021 Bowling Green, Kentucky, tornado was accurately predicted, but insufficient action was taken by residents, resulting in 88 deaths. When tornadoes strike at night, as this one did, and in an unexpected time frame (December), residents are more likely to miss the warnings. Tornadoes at night are 2.5 times as likely to result in fatalities, research shows.

Shelters as community assets. Shelters that provide community benefits year round—instead of only during a disaster event—not only offer co-benefits to the community but may also be better maintained and garner a stronger return on investment. For example, fairground staff, campers, and even musical groups have made use of the tornado shelter designed for Iowa's State Fair Complex.

Project Profile

Hurricane Shelters, Hancock County, Mississippi

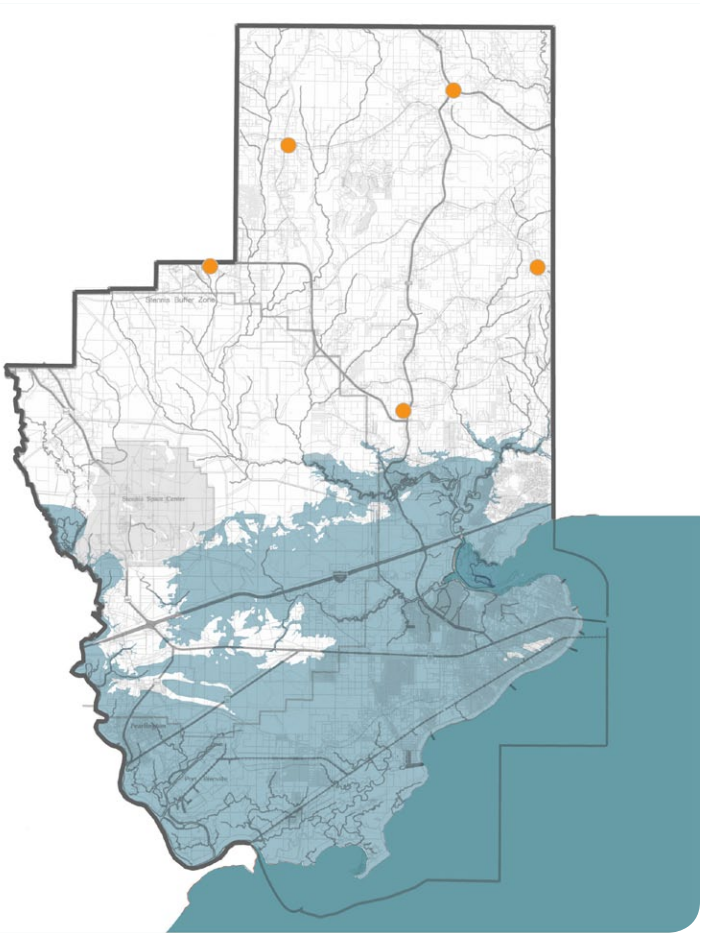
Hurricane Katrina made landfall in Hancock County in October 2005, bringing with it 125-mile-per-hour winds. After the storm, the county commissioned five shelters using FEMA funding, designed by unabridged Architecture.

The architectural design directs wind over and around the structures, which are rounded in plan and section and have berms to deflect wind-borne debris as an added protection for the 12-inch concrete walls (a design feature encouraged by FEMA). The concrete walls support a curving roof, eliminating edges that could catch the wind. The superstructure is steel, and the end walls are highly-reinforced concrete masonry units, with louvers for failsafe ventilation.

Continuity of operations systems include sewage chambers, potable water storage, and diesel generators that support the community when disaster strikes. A ground-source heat exchange system is also included to reduce the demand on the generator.

The shelters operate as single-use facilitates—a practice that FEMA is slowly changing—but the architect designed the large shelters to allow for a high-school regulation-sized basketball court, recognizing that the shelters were frequently located adjacent to baseball fields or other county recreational facilities and could serve a year-round purpose for the community in the future.

After Hurricane Katrina, Hancock County commissioned five shelters to protect the community during high-wind events. *(unabridged Architecture)*



The orange dots on this map indicate the locations of five Hancock County shelters; the blue indicates the extent of Hurricane Katrina's storm surge. Shelters located outside the floodplain can be used for both tornado and hurricane events. *(unabridged Architecture)*

Water Stress and Drought

Drought in the American Southwest has become so severe that it is now the driest two decades in the region in at least 1,200 years. Globally, all continents except Antarctica are facing unprecedented levels of drought.

Neighborhood-scale resilience strategies for drought address both water supply and demand. Water efficiency strategies, such as leak repair, often offer the most cost-friendly approach to addressing drought and are therefore a frequent starting point. Systems that provide alternate supplies for water, such as filtration and reuse, are useful and effective but are far more costly and burdensome to develop. Alternate water supplies are also highly regulated because of safety concerns, and regulations vary among states. Neighborhood-scale resilience strategies for drought also offer the opportunity to recharge groundwater and invigorate natural systems.

Table 5 includes a summary of several neighborhood-specific drought-resilient strategies. The following resources contain more information:

- *Growing Water Smart* guidebook and workshops, Sonoran Institute
- *Resilience Strategies for Drought*, Center for Climate and Energy Solutions
- *Harvesting the Value of Water*, ULI

"Conservation and efficiency improvements are the most cost-effective and least environmentally damaging ways of meeting new water demands."

—Sandra Postel, *Replenish*

Rainwater catchment pond for irrigation in Taoyuan, Taiwan.

Table 5: Neighborhood-Scale Resilience Strategies for Water Stress and Drought	
Green infrastructure	Implementing green infrastructure throughout a neighborhood, such as rain gardens, vegetated swales, tree trenches, restored wetlands, or other waterways, in addition to rainwater capture and reuse systems, can help rainwater infiltrate back into the soil rather than run directly into sewer or stormwater systems, thereby recharging groundwater and maintaining the hydrologic cycle. **Co-benefits and tradeoffs: green infrastructure also helps reduce stormwater flooding by increasing absorption and slowing the flow of water.**
Permeable pavement	Permeable pavement, used in place of traditional asphalt or concrete, allows water to return to the soil. Doing so will help recharge groundwater and allow the water to remain within the ecosystem. **Co-benefits and tradeoffs: similar to green infrastructure, permeable pavement also helps reduce stormwater flooding.**
Leak repair	Municipalities can invest in systems to detect and repair leaks to avoid inefficiencies in the water distribution system, potentially saving thousands of gallons of water and revenue. For example, the Marin Municipal Water District's leak detection team has saved the district almost 30,000 gallons of water per day.
Protection and restoration of watersheds	Protecting watersheds where water supplies originate allows the water cycle to be replenished and repaired. At the neighborhood scale, this could include conserving significant tracts of land as parks or designing master-planned developments appropriately to ensure they preserve adequate open space for groundwater recharge.
Water reuse	Graywater is reclaimed wastewater that can be used for specific, nonpotable purposes, such as outdoor irrigation, industrial use, or to fill toilet bowls. Municipalities can offer reuse of reclaimed graywater—typically carried in purple pipes to distinguish the recycled resource from fresh, potable water—from municipal wastewater treatment facilities to reduce strain on drinking water supplies.

Considerations and Challenges

Water efficiency comes first. Begin with water efficiency before moving to alternate supplies of water. Even though there are new technologies for treatment, recycling, and reuse of wastewater, it is far more efficient and productive for drought mitigation to begin with curbing existing water use and reducing waste.

Ecosystem-level storage brings co-benefits. Using strategies that bring more water back into the ground and ecosystem will better prepare the environment to absorb climate shocks in the future. Protection of natural ecosystems will ultimately allow communities to be more resilient not only to droughts, but also to floods and wildfires, because wetter soil is less prone to flash flooding and helps vegetation resist ignition.

For more on water-smart development strategies, read *Water Wise: Strategies for Drought Resilient Development*.

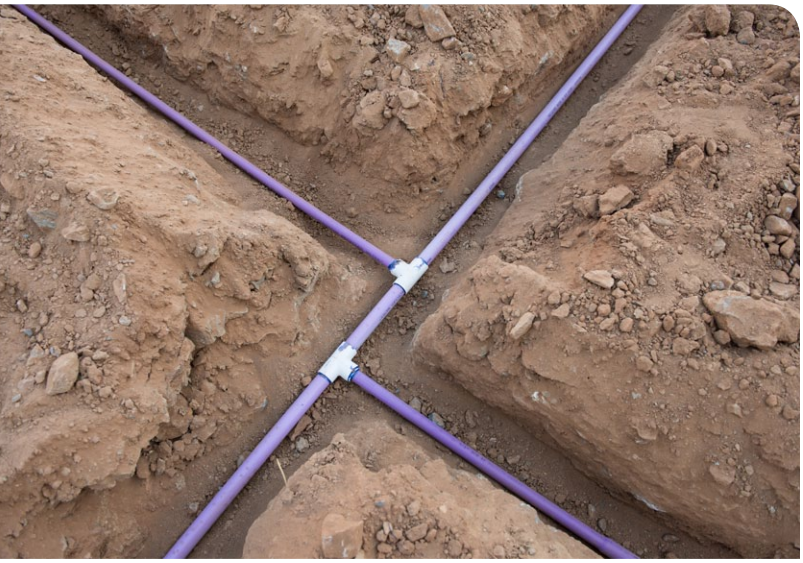
Project Profile

Mueller Neighborhood, Austin, Texas

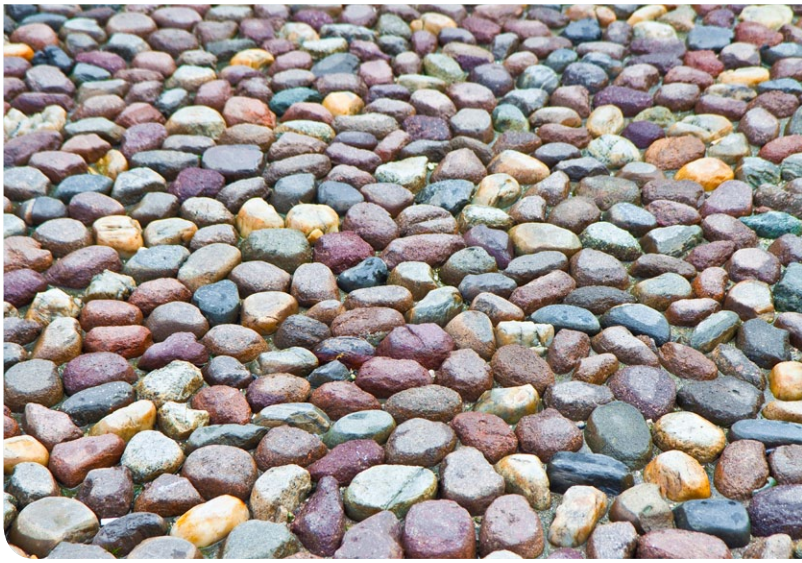
The Mueller neighborhood in Austin, Texas, is a sustainable, transit-oriented community designed to mitigate the effects of climate change, including drought and extreme heat. Built on the former site of the Robert Mueller Municipal Airport, it features thousands of new trees to mitigate the urban heat island, a water filtration system of "purple pipes" to reuse reclaimed water and prevent drought or water shortage, and native and adaptive plants to help with cooling and water absorption.

In addition to these hazard-mitigation measures, rooftop solar panels provide energy and decrease reliance on the power grid, as well as cut back on energy use overall. Bike paths and walkways are on every street to reduce the dependence on cars and funnel people toward mass transit options, further reducing emissions as well as waste heat and creating a better outdoor experience for residents.

Mueller was recognized by the U.S. Green Building Council as the largest neighborhood in the world and the first in Texas to become certified for Stage 3 Leadership in Energy and Environmental Design for Neighborhood Development (LEED ND) Gold under its pilot program in 2016.



Municipalities can offer reuse of reclaimed graywater—typically carried in purple pipes—to reduce strain on drinking water supplies.



Permeable pavement allows water to return to the soil, recharging groundwater.

Wildfire

In 2020, the United States had its worst wildfire season on record, surpassing the catastrophic wildfires in 2017 and the 2018 Camp Fire, both of which had set records for property damage and destruction. The hundreds of fires in the Mediterranean region in 2021, fueled by an extreme heat wave, were called the "greatest ecological disaster in decades." Multiple studies point to a longer wildfire season, with hotter temperatures and more extreme fires, both in the United States and across the globe.

As ULI's *Firebreak: Wildfire Resilience Strategies for Real Estate* notes, modern wildfires are unusual for both their scale of destruction and for their occurrence near developed areas. Communities that had previously not considered wildfire mitigation strategies are now seeking strategies to make themselves more resilient to wildfire.

Both climate change and forest management procedures have changed the look and feel of wildfires and their ability to spread rapidly, putting more communities at risk. Court cases have also shown that future development and planned communities must take hazards like wildfire mitigation into account during environmental reviews—or be prevented from breaking new ground.

"Courts are holding up developments, restraining projects approved at the local level when it's perceived there's been inadequate consideration of wildfire risks, or insufficient mitigation efforts put in place. That is an interesting shift."

—Molly McCabe, chief executive officer, HaydenTanner LLC

As seen at Rancho Mission Viejo, firebreaks can double as roads or bike trails, walking trails, or parks—community amenities that add value to the area. *(Jonnu Singleton/SWA Group)*

Firewise Community Designation

The National Firewise Communities Program encourages partnerships among a wide range of stakeholders to develop and implement proactive local solutions for wildfire preparedness and establishes a Firewise Community Designation. To be recognized as a Firewise Community, local communities must create and implement a plan with assistance from state forestry agencies and local fire staff and continue regular maintenance and education. The program provides a number of wildland-urban interface resources for firefighter safety, community planning, landscaping, construction, and maintenance.

Selected neighborhood-scale strategies for wildfire resilience are presented in table 6; the following resources have more information:

- Firebreak: Wildfire Resilience Strategies for Real Estate, ULI
- *Community Wildfire Safety through Regulation*, NFPA
- *Designing Communities for Wildfire Resilience,* SOM

Table 6: Neighborhood-Scale Strategies for Wildfire Resilience

Firebreaks and compact urban design	A firebreak is a gap in vegetation or other combustible material that serves as an obstacle to the spread of fire, such as a strip of open space in a forest. Firebreaks can be human-made, like a road, or a natural landscape, like a river, lake, or canyon. In communities that feature a compact urban design, firebreak lines can be created more easily around structures, and distance can be created from areas likely to burn. As an example of the overlaps between smart growth and hazard mitigation, an urban growth boundary can be modified to include firebreaks. **Co-benefits and tradeoffs: Firebreaks can double as roads or bike trails, walking trails, or parks—community amenities that add value to the area. If designed with the greater ecological landscape in mind, they can have other benefits, such as creating an escape route from other hazards, managing stormwater runoff, or adding flood protection elements.**
Defensible space	Defensible space refers to a buffer between a building or community and the grass, trees, shrubs, or any wildland area that surround it. This space helps protect structures and neighborhoods from catching fire from embers, direct flame contact, or radiant heat. Defensible space can be integrated into subdivision layout standards, homeowner association rules, or planning and zoning regulations, by requiring structures in high-risk areas to be separated by a safe distance when feasible to reduce wildfire spread and to have a maintenance plan and code in place to keep areas around structures clear.
Vegetation management	Vegetation management is the targeted control and elimination of unwanted vegetation that could serve as fuel and spread wildfires. Vegetation management increases the defensible space of a property or community and can mitigate the spread of a fire when done properly. It includes hazard tree identification and removal and minimizing the establishment of incompatible species under and near power lines. Restoration of native plants adapted to wildfire in landscaping can also play an important role.

Table 6: Neighborhood-Scale Strategies for Wildfire Resilience continued

Microgrids and buried wires	Power grids can inadvertently spark wildfires, as happened with California's Camp Fire in 2018. As part of a larger regional effort, grids can lay wires underground, especially in high-risk wildfire areas, to reduce the risk of ignition. Many communities with aboveground wires have resorted to Public Safety Power Shutoffs to reduce the chance of ignition when wildfire risk is at its peak, creating blackouts that disrupt everyday life. Regional power grids can be supplemented by smaller, isolatable "microgrids." These smaller grids, powered by local renewable energy, generators, or batteries, can be disconnected from the larger power grid and switched to a local energy source during an outage, resulting in fewer local blackouts. **Co-benefits and tradeoffs: Microgrids can also provide backup power in other hazard events and, when powered by renewable energy, reduce carbon emissions. Underground utility wires are also less likely to be damaged by other climate disasters, like storms, high wind events, and earthquakes.**
Multiple access points	Communities with many ways in and out are better equipped to manage movement of residents and emergency services during wildfire events.
Community shelters	Communities can create or identify fortified structures that can serve as refuges in the event that an evacuation cannot occur in a timely manner. This was seen in Paradise, California, during the Camp Fire in 2018: residents took temporary refuge in structures that could be easily defended, such as the Paradise Alliance Church, which had been scouted and fortified in advance as part of the town's emergency planning.

Considerations and Challenges

Collaboration. Challenges for wildfire mitigation are similar to challenges faced by other hazards: measures require enormous political will and buy-in, and the siloing of government agencies and private actors means that encouraging collaboration is critical. Recent high-profile wildfires have increased the willingness of communities to take action. Many neighborhood-scale mitigation strategies have strong interest from the private sector and real estate to protect lives and properties and to avoid legal backlash against development, which could create ripple effects on property value and availability of insurance. Collaboration across all parties is necessary to ensure communities can thrive in the face of wildfire risk.

Balancing density. Adding infill development to an already densely populated area can reduce development in the wildland-urban interface while creating opportunities for firebreaks. Density can also increase access to community resources like schools, commerce, and major roads.

However, density also presents its own risks, with the potential for houses to serve as additional wildfire fuel and contribute to wildfire spread. For example, too-closely built homes expedited the spread of the 2021 Marshall fire in Colorado. Where applicable, 12-foot distances between houses can help reduce wildfire risk.

Project Profiles

Resilient Recovery, Paradise, California

After the 2018 Camp Fire burned for two weeks and took the lives of 85 Paradise residents, displaced tens of thousands of people, and destroyed 19,000 homes, businesses, and other structures, a major recovery was needed for the 65 percent of residents who indicated they wanted to return.

A group was convened to manage long-term recovery and improvements for wildfire resilience, including a community engagement effort that comprised relationship building, listening sessions, and surveys to hear from residents about what changes they wanted to see. Through this community engagement process, residents and stakeholders helped define the plan's 40 recovery projects, including the following:

- An early warning system, undergrounding of utilities, removing debris, and replacing old infrastructure;
- Improving evacuation routes by widening roads and building a pedestrian and bike system that serves as a firebreak and doubles as secondary access/egress for emergency vehicles when needed; and
- Building-design standards and improvements to the existing wildland-urban interface code.

A full list of completed projects is available here.

Vegetation Management and Wildfire Fuel Reduction, Prescott, Arizona

Located in a very hot, dry climate with a high risk of wildfire, the Prescott Area Wildland-Urban Interface Commission (PAWUIC) is a nonprofit with a focus on vegetation management and wildfire fuel reduction on public and private lands. The program provides financing for vegetation management for low-income residents of a forest-adjacent town. Homeowners provide 10 percent up front to begin the risk reduction work, and after an inspection, the project advances the remaining 90 percent.

Since 2007, PAWUIC has distributed more than $18 million to reduce wildfire fuel on private property. For example, the Bradshaw project is a vegetation management project that encompasses the Prescott area, which includes about 141,156 acres in one of the largest wildland-urban interface areas in the U.S. Southwest. It is credited with protecting 28,000 homes for more than 53,000 residents.

The program has helped 43 local communities representing more than 18,000 parcels receive Firewise USA recognition. For example, PAWUIC conducted home wildfire assessments and tree thinning on 17 acres for Project Andrew. This effort was in collaboration with the Prescott Fire Department and Arizona Department of Forestry and Fire Management and helped the community achieve Firewise recognition. To further assist these communities, PAWUIC has successfully advocated for homeowners insurance premium reductions for local Firewise communities.

Policy: Planning for Neighborhood-Scale Resilience Efforts

Adding climate considerations to development regulation can be difficult, because it requires a great deal of coordination and can spark backlash from private or community stakeholders, incurring steep political costs.

The absence of a national climate adaptation plan that coordinates resilience efforts across government agencies and provides a reference point for state, local, and tribal governments as well as the private sector further complicates resilience building efforts. The federal government has numerous grants, technical assistance opportunities, and agency directives to enhance resilience. But much of the prioritization and project implementation is left up to individual municipalities, which vary in their level of risk awareness, as well as the capacity and political will to carry strategies out.

Despite these barriers, there are examples of regulations that can be leveraged to reduce hazard risk and foster the development of thriving communities.

Zoning

Zoning laws are one way to guide new development to be more resilient to climate disasters. Zoning laws are citywide but apply different standards in different areas of the city, designated by development or land use context, and affect entire communities rather than focusing on individual buildings. Local governments can modify zoning rules to avoid building new construction in high hazard areas such as floodplains or the wildland-urban interface and direct development and growth to safer locations. For future development, zoning regulations can be an effective tool in moving residents and businesses to lower-risk areas.

Summit County, Colorado

Summit County, Colorado, has mitigated its wildfire risk by creating new zoning policies in excess of minimum requirements. The Summit County Wildfire Council updated the county's land use and development code to include revisions to both zoning and subdivision regulations, which was approved by the county in 2018.

These standards include submittal of a forest management plan and a fuels reduction or defensible space plan that includes proposed mitigation. Defensible space provisions were integrated throughout the landscaping regulations, including adjustments to the minimum planting requirements and tree preservation standards to comply with defensible space fuel reduction zones.

Moreover, subdivisions will now be required to have a fuel reduction/forest management plan developed in consultation with the Colorado State Forest Service, U.S. Forest Service, or local fire protection district. This includes secondary fire apparatus access and emergency water supply and a long-term maintenance plan.

Because most municipalities have existing zoning laws that do not account for future climate risk, retroactively updating entire zoning codes can be a challenge. Overlay zones are one way to address this challenge. Overlay zones apply a new zoning district over one or more previously established zoning districts, with additional standards and criteria, such as enhanced flood protection requirements in waterfront areas. These can be mandatory or opt-in, with the goal of incentivizing development that exceeds minimum standards.

The difficulty notwithstanding, multiple communities have begun adjusting zoning to respond to changing climate conditions. Norfolk, Virginia, revised its zoning ordinances to mitigate flooding and promote safer development. In 2018, the revised ordinance included new zoning requirements to encourage investment in less risky areas and increase elevation and other requirements for new buildings in the flood zone. Boston's Coastal Resilience Guidelines and Zoning Overlay District (Article 25A) created a zoning overlay to protect residents and property from sea-level rise and associated storm surge by requiring enhanced resilience review for buildings in flood-prone areas. Santa Fe, New Mexico, also created an overlay district in which homeowners can only landscape with fire-resistant vegetation and the city is permitted to routinely thin trees to cut back on potential fuels.

Another way to use zoning regulations for hazard mitigation is to assign a point system with a variety of options for complying with minimum standards. For instance, St. Petersburg, Florida, used a point system for multifamily residential housing in coastal high-hazard areas. The point system was created through the city's Land Development Code to give developers a menu of resilience measures to choose from that protected against floods and storm surge.

Austin, Texas

Austin, Texas, has demonstrated how neighborhood-scale resilience strategies and building-scale strategies can work together to reduce vulnerability to wildfire. On the neighborhood level, Austin designated nearly 30 percent of city land as conservation lands, which limits the number of future structures at risk within high-hazard areas. On the building scale, Austin created and implemented the Wildland-Urban Interface Code for new and remodeled structures, including measures for ember protection and structure hardening. Austin, one of the most vulnerable cities in the country to wildfire, is notable for being a municipality outside of California to take such measures and can serve as a model for other urban areas in the country.

How can policymakers and other stakeholders prioritize racial equity in climate adaptation? Learn more from Centering Racial Justice in Urban Flood Adaptation.

Subdivision Regulations

Subdivision regulations can regulate the pattern and layout of new master-planned developments. These can be leveraged for resilience by requiring certain hazard mitigation efforts. For instance, in the case of wildfire mitigation, these policies can require multiple access points, sufficient water supply, vegetation control, and specified setback distances. The regulations can also direct new buildings away from high-wildfire-risk areas and toward safer low-wildfire-risk areas.

Property Buyouts

Buyouts—also called acquisition—refer to government purchases of homes and buildings in floodplains, wildfire-prone regions, or other high-risk areas in order to relocate residents to safer ground. This can be especially effective as flood risk mitigation, as discussed in ULI's *On Safer Ground: Floodplain Buyouts and Community Resilience* report.

Buyouts can provide long-term value to a community: FEMA found a sevenfold savings for every dollar spent on acquisition and demolition of homes in areas prone to river flooding. Charlotte, North Carolina, has a floodplain buyout program dating to 1999, which has purchased more than 450 buildings and saved millions of dollars. Since its inception, over 700 families and businesses have moved to less vulnerable locations outside local floodplains; 185 acres of public open space has been "undeveloped" to allow the floodplain to function during heavy rains and provide a long-term community asset. These buyouts are estimated to have avoided $25 million in losses and will ultimately avoid over $300 million in future losses.

Buyouts are occurring across the country in response to a wide range of hazards. Cedar Rapids, Iowa, completed the voluntary acquisitions of 1,500 properties, restoring the flood-prone land to 220 acres of open space. Though property costs in Cedar Rapids are more affordable than in some coastal regions, there are buyout efforts underway in areas with higher property values as well. The New Jersey State Blue Acres Floodplains Acquisitions program is an effective pathway for acquisitions and buyouts in a coastal region, helping adapt to coastal and inland flooding after Hurricane Sandy struck in 2012. Similarly, in rebuilding Paradise, California, after the Camp Fire, the locality purchased 300 acres of new land, with about 500 more acres in the pipeline for the highest-risk properties for wildfire. Though not linked to climate risks, Hawaii acquired eligible properties impacted by the 2018 Kilauea eruption to reduce risks from future eruptions, through the Voluntary Housing Buyout Program.

Despite these examples, buyouts continue to require significant public support and upfront capital to make the purchases, which is not always available in all real estate markets. It also takes significant political will to refuse to rebuild someone's neighborhood in an effort to reduce exposure to future devastation, which local leaders are not always willing to do.

Managed Retreat

Managed retreat is a strategy to gradually relocate residents from a high-risk area, usually a floodplain, orchestrated by a municipality. Managed retreat's gradual nature allows more flexibility for individual property owners' location decisions over a longer time range. It can also be used for other climate hazards, such as wildfire.

A managed retreat allows the locality to support residents who want to make a change to a safer location but who may not have the means to do so. Similar to buyouts, a managed retreat requires a great deal of political will and faces backlash. Managed retreats, like buyouts, can cause sociological and emotional tension, especially for communities that rely on the proximity to water as part of their livelihood, or those who enjoy the wooded rural landscapes and do not want to relocate away from wildfire risk. The rate at which the managed retreat happens also matters and can inadvertently penalize those who are less willing to move. The holdouts in a managed retreat can request more concessions, penalizing those who cooperate earlier.

Examples of managed retreats exist in the Isle de Jean Charles in Louisiana and the Quinault Indian Nation village of Taholah in Alaska, both of which encouraged Native communities to leave floodplains for lower-risk land further inland. The Bureau of Indian Affairs worked with the Taholah to find a second location inland and supported an inland migration strategy in which a second community is in development for the population to transition to

over time. However, community-scale relocations are costly, often requiring significant support from larger funding sources such as federal grants.

Transfer of Development Rights

One strategy to curtail development in high-risk areas is through the transfer of development rights (TDR). Under TDR, property owners in high-risk areas are permitted to sell the development rights from their land to an interested party with the goal of increasing density in safer locations. This can work well for hazards such as wildfire or flooding and directs future development and population growth out of harm's way.

For example, Charlotte County in central Florida uses a program that shifts residential density from high-risk areas to land deemed safer for development while preserving environmentally sensitive lands. The intention is to encourage the removal of old, outdated, platted lots and subdivisions and incentivize development with compact, higher-density, mixed-use development that is more sustainable and uses resources efficiently.

To be most effective, a TDR program needs to generate value on both sides of the exchange. If demand for the development is not sufficient, then the program's value is likely to decrease.

Finance: Paying for Neighborhood-Scale Resilience Strategies

Financing neighborhood-scale resilience strategies is often a hurdle for any community and can be an especially significant barrier for lower-resourced communities. These communities may lack personnel dedicated to grant writing or may be unfamiliar with navigating complex government funding processes. ULI's companion report, *Resilient Retrofits: Climate Upgrades for Existing Buildings*, recommends phased implementation of retrofit strategies as one way to help spread costs out over time, a strategy that can also support implementation for neighborhood-scale solutions.

For many localities, securing financing will be critical to bringing resilience strategies within reach. As discussed in the "Business Case" section of this report, lack of action by cities to address their climate risks could result in the downgrade of future bond ratings. As the frequency and intensity of climate events rise across the country, localities will need to be more proactive or face an increased cost of capital. Identifying creative ways to finance resilience strategies now will only benefit communities in the long run. This section discusses ways of funding and financing such projects.

Public Capital Expense Budgets

For the communities able to finance a neighborhood-scale resilience solution, a business case can be made for doing so ahead of disasters: taking action now will save more in the long term, and if cities can afford to dedicate upfront capital expenses toward climate adaptation, the increased costs of repaying loans can be avoided. Further, localities that invest in resilience are more attractive to investors, which is discussed in more detail in the "Business Case" section of this report.

Cities can use their capital, operating, and maintenance dollars for more resilient infrastructure, parks, tree canopy, roads, and so on. Efforts to pay for neighborhood-scale resilience strategies may be more successful in regions where strong political will exists for such strategies, either because of an enhanced understanding of climate risk or because of the recent memory of a climate disaster.

Cities that have experienced significant impacts from climate events, such as New York City and Miami, have enshrined numerous capital projects for risk mitigation in their long-range planning. Strategic or resilience plans, such as New York City's OneNYC 2050 and Miami's Resilient305 plan (which includes the city, surrounding county, and neighboring Miami Beach), detail the actions each municipality will take to address climate risks in the public realm, such as mitigating coastal flood risks or hardening critical infrastructure, and how these strategies will be funded from city budgets.

There is concern from local governments on how climate change can compete against other community priorities—many of which also are in need of capital funding—and how to ensure climate adaptation projects remain funded after COVID-19 severely affected city budgets.

Impact Fees

Some communities use impact fees such as stormwater utility fees to fund hazard mitigation efforts. For instance, Charlotte-Mecklenburg Storm

Water Services leverages stormwater utility fees to create a perennial revenue source for flood control infrastructure, including buyouts. Revenue generated by the fees almost entirely funds its Floodplain Buyout program, which has acquired over 400 properties and created 185 acres of protective open space, avoiding an estimated $25 million in damages since 2003.

Bonds

Municipalities can issue bonds as a way to raise money for capital projects and improvements, and many localities with a strong bond rating can easily access the funds. Bonds are an example of debt financing, where the credit rating of a municipality guarantees its repayment without significant upfront capital expenditures. For example, Miami, Florida, has raised a $400 million general obligation bond for resilience projects, known as Miami Forever. Flagstaff, Arizona, has also used $10 million in bonds for wildfire and flood mitigation through forest management.

Two types of bonds that can be issued with the express purpose of environmental or climate improvement or physical risk mitigation are green bonds and environmental impact bonds. Green bonds are municipal bonds that are used to support climate-related or environmental projects. An environmental impact bond (EIB) is a type of municipal bond with increased transparency and accountability embedded in the bond structure. Distinct from green bonds, returns are tied to performance of the infrastructure invested in. EIBs allow a bond's potential investor base to include environmental, social, and governance (ESG) funds and accounts. The project must demonstrate commitment to innovation and transparency to peers and the community, and it must include nature-based solutions, which drive additional resilience benefits.

A prominent early implementer of this performance structure, Washington, D.C.'s Water and Sewer Authority (DC Water) structured and executed a $25 million EIB, the country's first, to address sewage overflows into the Potomac River. The city had aging infrastructure and regulatory and environmental concerns from its reliance on a sewer system that combined stormwater and sanitary sewage within a single system. DC Water was subject to a dispute with the U.S. Environmental Protection Agency to address its combined sewer overflows problem and developed a multibillion-dollar green infrastructure plan and relied on the EIB to finance it.

In 2021, DC Water fully repaid the EIB. An evaluation confirmed the effectiveness of green infrastructure in the District with future optimizations for green infrastructure at DC Water. The success from this EIB funding mechanism lays helpful groundwork for how to navigate upfront investment in a new approach with a lot of uncertainty.

Challenges remain in defining what can be considered "green." Greenwashing is the concept of requesting funds for projects that may appear to be climate related but are only tangentially related. As green bonds and environmental impact bonds become more popular and easily accessible, scrutiny is increasing as to how the funds are being spent. Developments such as the Sustainable Finance Disclosure Regulation in Europe are expected to assist with distinguishing high-quality, climate-focused investments.

"Municipalities that are proactively orienting their project towards more sustainable and resilient outcomes will have a huge tailwind as federal and state funding focuses more intensely on addressing climate change and emissions reductions. Access to more grants and larger funding sources is a very big carrot for local governments."

—Taylor Ralph, REAL Building Consultants, Tampa

Federal Grant and Loan Programs

Multiple federal funding sources are available to help communities implement neighborhood-scale resilience strategies. Some of the most prominent sources are discussed in the following section.

BRIC Program

FEMA launched the Building Resilient Infrastructure and Communities (BRIC) program to provide funding for pre-disaster mitigation. The BRIC program saw significant expansion in funding in 2021 under President Joe Biden and has funded nature-based restoration and infrastructure projects across the country, from stormwater parks and wetland construction to a tsunami evacuation tower. A selection of funded projects is available in FEMA's Hazard Mitigation Portfolio.

FEMA Flood Mitigation Assistance Grants

Flood Mitigation Assistance (FMA) grants fund projects that reduce flood risk to properties and structures insured under the National Flood Insurance Program, including community flood mitigation projects such as stormwater management, wetland restoration or creation, and floodplain and stream restoration. One example is Sebastian County, Arkansas, which secured a $25,000 FMA grant in 2015 to update its Flood Hazard Mitigation Plan with several nature-based solutions, such as planting trees and installing green roofs to manage stormwater and mitigate extreme heat.

HUD Community Development Block Grants

The Department of Housing and Urban Development (HUD) provides Community Development Block Grant Disaster Recovery (CDBG-DR) funds to help cities, counties, and states recover from presidentially declared disasters. While helpful for recovery, the funds are subject to availability of supplemental post-disaster appropriations and cannot proactively address disaster risk the way BRIC funds can.

Traditional CDBG funds that are not part of a disaster recovery package are intended to support community needs such as affordable housing and economic development. These funds can be used creatively to meet both community and climate resilience needs. For example, in 2014, Detroit received an $8.9 million block grant to demolish abandoned properties, plant trees on 200 vacant lots, and install a bio-retention basin. This project improved stormwater management and the vibrancy of the neighborhood.

Revolving Loan Funds

A revolving loan fund (RLF) is a longstanding mechanism for clean energy financing and has been used for coastal restoration in some states for decades. RLFs can be used by individual property owners, groups of owners, businesses, or municipalities. After an initial investment is made in the fund by private investment or public capital, the fund provides loans with favorable repayment terms and little-to-no interest. As loans are repaid, capital is replenished and enhanced and loaned out to new recipients. The fees and repayment structure is far more favorable than bank loans tend to be, and revolving loans require less infrastructure to set up and apply for than traditional grant-making processes.

Many states have used RLFs to conduct water treatments under the Clean Water Act. However, they are also useful for specific resilience challenges. For example, RLFs have been used in Maryland since the 1970s to install coastal erosion and sea-level rise infrastructure such as living shorelines, and a similar approach is being explored in the Puget Sound region of Washington state.

RLFs are likely to expand in coming years. The Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act, passed in early 2021,

provided FEMA with $500 million to pass on in initial grants to states and tribal governments to capitalize RLFs for hazard mitigation projects. This financing source could be transformative for local resilience infrastructure.

"Revolving loan funds are the simplest way to finance pretty much everything, energy-wise. A lot of revolving loan funds were started to finance energy efficiency projects. When you make an energy efficiency improvement, the system operating costs are lower than they were before. The energy savings from that decrease can be used to pay the loan back, replenishing the fund. So then a new loan can be made. And if you can take away the interest rate, then this simple financing becomes even more attractive."

—Daniel Bresette, executive director, Environmental and Energy Study Institute

Credit and Credit Trading Programs

Instead of rebates, the option for "credits" can provide financial incentives to reduce physical risk as well as motivate behavior to encourage better use and stewardship of resources. For example, a stormwater credit program in Philadelphia allows customers the ability to reduce their monthly stormwater charge in exchange for managing stormwater on site. Or, in the case of Washington, D.C.'s Stormwater Retention Credit Trading Program, properties located in neighborhoods served by a municipal separate sewer system (or MS4, a system in which stormwater flows into waterways without any treatment) are encouraged to develop green infrastructure and sell credits for their implementation to properties that cannot build their own. This credit trading ability helps incentivize green infrastructure creation by monetizing its value beyond individual properties.

Land Value Capture

Land value capture allows communities to invest land value that results from public investment and government action. Land value capture rests on the idea that if a property owner or developer receives a financial benefit from infrastructure such as new roads or parks, they should share some of the profit. This approach could be used to fund neighborhood-scale resilience projects, such as coastal infrastructure, that protects properties. The developers who see increases in property value could pay a fee, to be used to pay off the bond issued to finance the infrastructure development. However, to date the land value capture approach has not been used significantly for resilience efforts.

Tax Increment Financing

Tax increment financing (TIF) is a method of financing a project based on the anticipated increase in property taxes. TIF is concentrated in a designated geographic area—municipalities can have many TIF districts. Chicago has designated over 120 TIF districts, which have attracted $6 billion in private capital investments. Revenue from Chicago's Central Loop TIF funded the city's Green Roof Improvement Fund, to incentivize installing green roofs to manage stormwater. TIFs can be a source of equitable adaptation financing if the higher property costs do not displace local residents, or if the costs are not disproportionately borne by low-income residents.

Other tax opportunities to support investments in hazard mitigation are discussed in the National Institute of Building Sciences' *Roadmap to Resilience Incentivization*.

Community Rating System

The National Flood Insurance Program Community Rating System (CRS) was implemented in 1990 to recognize and encourage community floodplain management. Joining programs like CRS allows for discounts on flood insurance premiums. Flood insurance premium rates in CRS communities are discounted in increments of 5 percent. By opting in and taking specific actions to reduce flood risk, property owners receive discounts on their insurance premiums.

Resilience Authority

A system unique to Maryland, several counties in the state have or will create a Resilience Authority, a quasi-governmental agency that can seek grants, issue bonds, and even levy fees to carry out infrastructure projects that reduce impacts of climate risk. As an independent body, the authority's funds would not compete with public spending on other priorities like schools, health, or safety. Resilience authorities are a recent creation, and little precedent exists for how they may be structured or how effectively they can tackle adaptation needs, but attention is being paid to Maryland's experiment in multiple jurisdictions looking for creative means of funding thorny risk mitigation needs.

Public/Private Partnerships

Public/private partnerships are collaborations between a government agency and one or more private-sector partners. Private entities can use their expertise and resources to assist government partners, particularly in the area of procurement and implementation. In smaller localities that have fewer dedicated staff and resources for financing, a public/private partnership can help get projects off the ground and explore funding streams that would otherwise be harder to reach.

For instance, in the Prince George's County Clean Water Partnership, a private company (Corvias) partnered with Prince George's County in Maryland and the city of Chester in Delaware to improve stormwater management practices. The initial goal was to retrofit 2,000 acres of property for the purposes of stormwater management, while emphasizing providing employment for local, under-represented communities. The program delivered the 2,000 acres in half the time for half the price, while generating over 200,000 hours of work. Because of the success of the first project, the Clean Water Partnership between Prince George's County and Corvias was extended 30 years for 4,000 acres.

A vegetated gravel swale in MacRitchie Reservoir Park, Singapore, channels rainwater into the drainage network and filters pollutants to enhance the city's water quality.

Conclusion

Neighborhood-scale resilience measures are a complicated process that involves close collaboration between public and private entities and different branches of government. Many localities are just beginning to see the need for tackling resilience with community-wide measures. Policies that support such efforts can move projects forward, but mustering political will and financing for such measures can be daunting, particularly when such action can be disruptive and costly in the short term.

Nonetheless, existing efforts for neighborhood-scale mitigation efforts prove promising and provide valuable lessons on how such action can be achieved. In examining what works, the examples in this report show that communities are recognizing their climate risk, understanding the business case, and are taking action to protect their populations and their properties.

As funding opportunities continue to increase and the social, environmental, and financial consequences of climate risk grows, governments, real estate actors, and the general public will increasingly turn to neighborhood-scale resilience strategies to protect their communities.

"We are at an incredible inflection point in the practice of urban development. Traditionally, the professions that support the urban development process have attributed the environment to the status of a known, fixed assumption established by measurement. We are now moving into a new era of systems modeling where we must move beyond a blind reliance on historic assumptions and yesterday's best practices."

—Uwe Brandes, professor of the practice, faculty director of the Georgetown Global Cities Initiative

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