



RESEARCH REPORT

Preserving, Protecting, and Building Climate-Resilient Affordable Housing

A Framework for Local Action

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HOUSING MATTERS
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Preserving, Protecting, and Building Climate-Resilient Affordable Housing

Climate change is already affecting housing availability, affordability, quality, and safety. Impacts from related environmental and weather hazards like rising temperatures, flooding, and more frequent and severe storms are projected to worsen in coming years as climate change advances (Quarles and Pohl 2018). These climate hazards are threat multipliers for housing affordability and accessibility as they reduce the availability of housing; increase the cost of building, maintaining, and accessing housing; and threaten the overall stability of neighborhoods amid a scarcity of affordable housing nationwide.

This document outlines a framework for climate-resilient housing that aims to articulate the impact of climate change on affordable housing and the opportunities for the housing sector to adapt to and mitigate climate hazards. It is informed by a growing body of housing-resilience literature and interviews with developers, policymakers, and advocates working to address climate and housing crises. The framework outlines challenges and opportunities across four pillars that influence housing resilience: policy and finance; neighborhood and community infrastructure; housing stock; and the social capital of individuals, households, and communities (figure 1).

Designed for those focused on housing development and policy, this framework aims to equip stakeholders with:

1. the language and an approach to bring together siloed insights from the sustainability, resilience, and environmental justice fields;
2. knowledge about important challenges and opportunities across the four pillars of housing resilience that can impede or advance climate-resilient housing in their communities; and
3. resources to help motivate and guide action to create more climate-resilient housing.

For each of the four pillars, the framework (1) introduces why the pillar matters for climate-resilient housing, (2) details the challenges that inhibit climate-resilient housing, and (3) outlines opportunities to advance climate-resilient housing at local and community scales. The framework concludes with an appendix of resources that can help local and regional housing actors build capacity and identify

planning, policy, and funding opportunities to preserve and develop climate-resilient housing in their communities.

FIGURE 1
The Four Pillars of Housing Resilience



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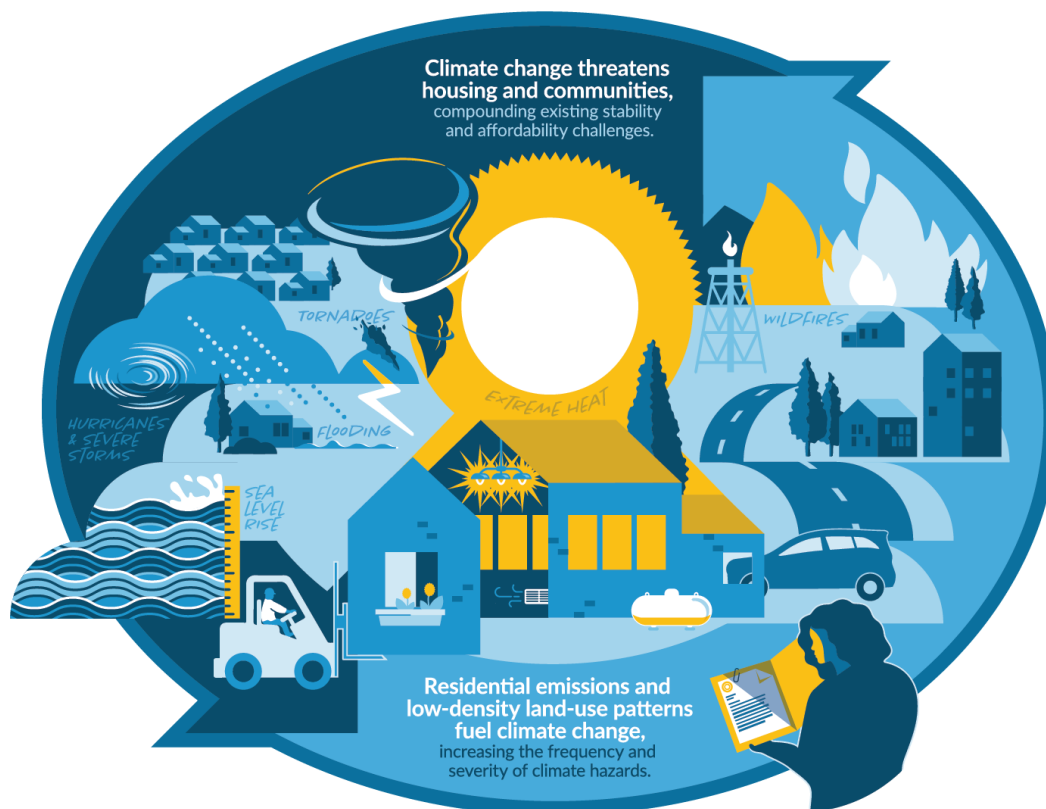
Source: Authors' analysis.

The Intersection of Housing and Climate Change

Although housing stock characteristics, housing development patterns, and climate risks and exposures vary across the country, all regions are affected by climate change. Climate hazards present a significant threat to the country's housing stock, with extreme weather and disaster impacts exacerbating property losses, repair costs, energy burdens, and housing quality concerns for owners and renters nationwide (Joint Center for Housing Studies 2023a).

At the same time, building new homes significantly contributes to the planet-warming emissions fueling climate change. The following themes, outlined below and in figure 2, highlight the interdependent relationship between climate change and our nation's housing.

FIGURE 2
Climate and Housing Intersections



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Source: Framework developed by the authors.

Climate Change Threatens Housing Stability and Affordability

The increased severity and prevalence of acute and chronic climate hazards are causing damage and loss of housing units across the market—constraining housing supply; increasing the cost of construction, rehabilitation, and maintenance; and burdening residents with the financial and social costs of damage and recovery.

CLIMATE HAZARDS LEAD TO DAMAGE AND LOSS OF UNITS, COMPOUNDING EXISTING HOUSING STABILITY AND AFFORDABILITY CHALLENGES

The housing market is already strained, with significant access and affordability barriers. For renters with extremely low incomes—those earning less than 30 percent of their area’s median family income—there is a national shortage of nearly 7 million available affordable rental homes, such that for every 100 extremely low-income renters, there are only 36 available rental homes that are also affordable (NLIHC 2022). Among homebuyers, high mortgage rates and high home prices relative to median incomes have restricted access to homeownership, leading to declines in home sales and new homeowners. According to the Federal Reserve Homeownership Affordability Index, homeownership is the least affordable it’s been since before the Great Recession.¹

Climate change is exacerbating these conditions, putting more households at risk of housing instability and displacement. In 2021, 14.5 million homes were affected by climate-related hazards such as hurricanes, wildfire, and hail, with the largest hazard events totaling \$56.9 billion in damages. Another 59.9 million homes were in areas expected to experience moderate levels of annual losses from climate-related hazards. The nation’s limited affordable housing stock is particularly at risk (Joint Center for Housing Studies 2023b). A recent study found that the number of subsidized and unsubsidized affordable housing units at risk of suffering damages from sea level rise and coastal flooding alone is expected to triple from 2000 levels by 2050 (Buchanan et al. 2020).

These damages have both financial and social consequences. In 2022, more than 3.4 million Americans were forced to evacuate their homes due to a disaster. While 40 percent returned home within a week, 16 percent of displaced adults never returned home and 12 percent were out of their homes for more than six months.² Ultimately, climate hazards are taking more housing units off the market, particularly older housing units in need of repairs that make up a substantial portion of the nation’s unsubsidized affordable housing stock, displacing residents, and pushing affordability further out of reach, especially for renters and owners with limited means.

THE RISE IN EXTREME TEMPERATURES DEEPENS ENERGY BURDENS FOR LOW-INCOME OWNERS AND RENTERS

Housing energy utility costs already disproportionately burden households with low incomes and households of color. Nationwide, Black and Native American households spend approximately 43 percent more and Latino households spend approximately 20 percent more on residential energy costs than white households (Energy Equity Project 2022). Among low-income households, approximately 60 percent—or 15.4 million people—experiencing high energy burdens qualify as “severely” energy burdened, spending over 10 percent of their household income on energy costs (Drehobl, Ross, and Ayala 2020).

Rising temperatures are increasing cooling costs for renters and homeowners and more intense winter storm events are increasing heating costs for some households. As temperatures continue to rise over the next century, cooling costs are expected to increase energy burdens, particularly for lower income households living in housing units and urban areas that lack building and neighborhood features like quality insulation and tree canopy coverage to mitigate extreme—but increasingly more common—weather conditions (Ortiz et al. 2022).

CLIMATE HAZARDS WORSEN HOUSING QUALITY AND INCREASE THE COSTS OF CONSTRUCTION, REHABILITATION, AND MAINTENANCE, DEEPENING HOUSING-RELATED HEALTH INEQUITIES

The increased severity and frequency of climate hazards creates and compounds housing quality issues. For example, extreme temperatures can expose poor ventilation and inadequate heating and cooling systems, while major storm events may lead to substantial repairs such as a roof replacement. These climate impacts have significant financial implications and present short-term economic shocks that can derail households with limited financial means and increase long-term housing costs due to increasing insurance premiums and higher construction and rehabilitation costs.

Climate related housing quality challenges also raise significant public health concerns for those most impacted, which are most often people of color and low-income populations.³ Higher rates of depression and anxiety are common with chronic exposure to poor housing quality issues associated with climate change, such as household mold from flooding or storm events (Shenassa et al. 2007). Posttraumatic stress disorder frequently occurs among people who are displaced from their housing following severe storm events and environmental disasters.⁴ Inadequate heating, cooling, and ventilation also put millions of people at risk of poor health outcomes, illness, and death.⁵

The Housing Sector Significantly Contributes to Climate Change

The housing sector is affected by climate hazards, but it also contributes to climate change. Residential energy use and low-density land use patterns account for a significant share of the nation's greenhouse gas emissions, fueling the conditions that make climate hazards more frequent, severe, and threatening to communities across the country.

RESIDENTIAL ENERGY USE

Residential energy use accounts for 20 percent of the nation's energy consumption.⁶ Reliance on natural gas for heating and cooling and fossil fuels like natural gas and coal for household electricity makes the residential sector a significant contributor to the nation's greenhouse gas emissions. Combined, the residential sector and commercial building sector account for 30 percent of US greenhouse gas emissions.⁷ While consistent improvements in energy efficiency have helped reduce household energy consumption, development trends toward larger-sized homes, transportation trends toward electric vehicles, and anticipated increases in cooling needs due to rising temperatures will continue to drive increases in household energy consumption.⁸ Maximizing residential energy efficiency and transitioning to lower- and no-carbon fuel sources are critical to reducing housing's climate impact and advancing housing sustainability.

LOW-DENSITY LAND USE

Low-density land use and housing development patterns amplify the residential sector's climate impacts. Where and how developers build housing greatly affects household emissions. For example, sprawling development patterns depend on passenger cars and increase the number of vehicle miles traveled for households and delivery services. Between 1990 and 2021, the number of vehicle miles traveled by passenger cars and light-duty trucks increased by 45 percent.⁹ Taken together, passenger cars and light-duty trucks are responsible for 58 percent of the transportation sector's greenhouse gas emissions, which account for 28 percent of the nation's overall greenhouse gas emissions.¹⁰ Housing-related land-use decisions like increasing housing density, building along transit corridors, and promoting more mixed-use development can help reduce per capita carbon emissions.

A Framework for Climate-Resilient Housing

There is an urgent need to transform our nation's housing stock to reduce its carbon footprint and make it more climate resilient. Our climate-resilient housing framework outlines recommendations for local

and regional action to support affordable housing development, retrofitting, and preservation that protects housing stock, maintains affordability, advances accessibility, and supports residents' financial, physical, and social-psychological health and well-being in the era of climate change. This framework is designed for local and regional housing developers, community planners, policymakers, and advocates. It outlines the key challenges and opportunities that can impede and advance climate-resilient and sustainable housing in communities, and explains four pillars of action to achieve housing resilience: policy and finance, neighborhood and community infrastructure, housing stock, and people and social capital. Enhancing climate resilience in housing holistically across the four pillars can help address barriers that characterize the status quo, such as limited funding, misaligned incentives, siloes across sectors and domains, and a lack of capacity and knowledge.

The framework can also encourage planners and policymakers to prioritize climate-resilient housing decisions and investments that address the twin goals of mitigation and adaptation while also advancing three key dimensions of environmental justice: distributive, recognition, and procedural equity (see appendix A for definitions and examples). Working across the four pillars and the multiple dimensions of equity, local leaders can prioritize investments that benefit those most affected by climate change, those most vulnerable to the effects of climate change, and those who have been marginalized or excluded from past housing and infrastructure planning and decision making. Climate-resilient housing investments that advance social and racial equity will prioritize these populations in planning decisions, engagement, and benefits while mitigating unintended and disproportionate consequences for these groups as new investment and planning decisions are considered.

To develop the framework, we conducted expert and key informant interviews with 18 housing policy experts from the federal, state, and local levels, as well as housing providers and housing lenders to understand the national landscape of climate-related hazards affecting housing stocks and markets. We asked about barriers to and opportunities for housing sustainability, resilience, and equity. We also asked what data and evidence were needed to advance climate-resilient and sustainable housing in the future. We also conducted a review of applied, practitioner-focused, and scholarly literature and resources targeted to planners, developers, and policymakers to plan for, preserve, or develop climate-resilient housing. Finally, we conducted a scan of existing federal and innovative state policies and programs targeted to enhancing resilience or sustainability for households, particularly low-income households and those living in affordable housing. The pillars are informed by the existing evidence base and experience of practitioners and together address opportunities to advance climate-resilient housing across different community scales and domains.

The Four Pillars of Housing Resilience

Below we define our four pillars of housing resilience. We outline why each pillar matters and the challenges and opportunities within each pillar and provide a field example of what advancing climate-resilient housing looks like in practice.

PILLAR 1: POLICY AND FINANCE



Policy and finance involve the land-use and zoning regulations and incentives, building codes, local housing ordinances, lending practices, insurance policies, and public and private capital flows that affect where and how a community builds and preserves its housing, what type of housing it builds, and who has access to that housing. The policy environment can encourage or impede the development of climate-resilient housing.

Why it matters: The policy environment influences community and household exposure to and protection from climate and environmental hazards. It also affects the following:

- access to resilience and sustainability resources and amenities, including transit and green infrastructure
- the types, size, and density of housing and the mix of unsubsidized and subsidized housing stock
- the types of materials, heating and cooling technologies, and energy efficiency and resilience standards used or required to build a home
- availability and affordability of insurance
- the eligibility requirements and processes that authorize who can access subsidies, mortgages, insurance, and other necessary components to housing access

A supportive policy environment can serve as a platform for the local and regional planning needed to mitigate and distribute risk, build the infrastructure to enable a resilient and sustainable lifestyle (e.g., transportation systems, green and grey resilience infrastructure), and provide the resources and protections to address inequities and ensure the most vulnerable are not left behind (e.g., environmental justice protections, targeted hazard mitigation, etc.). An unsupportive or agnostic policy environment can further entrench unsustainable building practices and land use patterns (e.g., sprawl, larger floor plans, cheap building materials), increase the number of households exposed to climate risks (e.g., development in the wildland urban interface, etc.), and deepen inequities (targeted policies towards homeowners not renters, prioritizing protections for wealthier neighborhoods).

Challenges: Given the scope and scale of the policy environment's levers of change—it affects zoning and building codes as well as financing and insurance—it has a tremendous influence on the future directions of building design, land use patterns, and community composition. The policy environment is largely responsible for codifying many of the inequities visible in the current make up of communities and buildings. Therefore, changes within the policy environment provide the opportunity to meet future needs while repairing past harms. However, land use, zoning and other policy levers have been underutilized in steering new development away from hazardous areas. Structures are often grandfathered into policy, building code, and zoning laws and therefore it can be difficult to leverage the policy environment to retrofit and upgrade existing housing stock. Furthermore, short term affordability goals are often in tension with sustainability and resilience goals in policy development, finance, and implementation. Misaligned incentives can also be a barrier to investment in sustainability and resilience improvements. For example, green retrofits to renter households face a split incentive challenge in which landlords must fund the retrofits but tenants benefit from the resulting reduced energy bills. These challenges can be addressed through policy development and coordination at federal, state, and local levels of government.

Opportunities: Policy changes at the federal, state, and local levels can be aligned to support climate-resilient housing, with each level playing a unique, but important role. Actors at the federal level play a critical role in setting national standards and providing capital needed to motivate and pay for change. The federal government has a large influence on the state and local enabling government, and the structure and complexity of their rulemaking, guidance, and funding streams can create barriers to the development of climate-resilient housing. To advance climate-resilient housing, federal changemakers can lead by example, encourage innovation, and provide the necessary resources to seed and scale models that work. For example, agencies can integrate sustainability and resilience requirements in federal investments and rulemaking and incentivize sustainability and resilience improvements through rating systems, guidance, and funding.

Actions at the state and regional levels are critical for coordinating efforts that require collaboration across local jurisdictions and for ensuring equitable outcomes. To advance climate-resilient housing, state and regional changemakers can create sustainability and resilience plans to align actions across jurisdictions, provide resources and build capacity for local jurisdictions to advance those goals, and support large-scale resilience efforts. This may involve advancing regional plans to guide resilient land-use patterns across jurisdictions, developing programs to build the capacity of local jurisdictions to take advantage of state and federal resources to advance their climate-resilience goals, and create state or regional coordinating bodies to lead large-scale resilience initiatives.

Local level policy development is vital to advancing climate-resilient housing. Local actors can establish regulatory policies like zoning and building code requirements that shape where and how housing is built; design and execute programs that provide financial, technical, and educational resources to equip residents, communities, and businesses with the capital and knowledge they need to build affordable and resilient housing; and leverage cross-sector partnerships to deepen impact and unlock innovation (see box 1). For example, local governments can raise the floor for developers, lenders, and residents to build climate-resilient housing through comprehensive planning, land use and zoning requirements, and building codes.

BOX 1

Case Study: Leveraging an Adaptive and Comprehensive Policy Strategy to Build Resilience in Norfolk, Virginia

To address increasingly severe flooding due to sea level rise and land subsidence, policymakers in the city of Norfolk, Virginia, have spent the last decade making interconnected and iterative changes to the enabling environment that are helping to shore up the city's resilience and continue its legacy as a vibrant coastal community. Through a combination of forward-thinking short-term planning (plaNorfolk 2030), ambitious long-term planning (Norfolk Vision 2100), and tactical changes to the city's zoning ordinance (resilience quotient scoring system and resilience overlays), Norfolk has set an example for other localities of how to leverage a policy environment to advance climate resilience. Key elements of their strategy include the following:

- Adding a flexible “Resilience Quotient System” to the city's zoning ordinance. With this system, developers accrue points for adopting resilience measures related to stormwater management, risk reduction, energy efficiency, water quality and conservation, urban greenery, and healthy lifestyles. To meet point requirements, developers can either choose from a preidentified list of resilience strategies or work with the city to design new actions that both meet developer- and project-specific needs and meet city requirements.
- Integrating “Overlay Zones” with different zoning requirements and incentives. This promotes growth in the in the least flood-prone areas (Upland Resilience Overlay) and increases resilience in the most flood-prone areas (Coastal Resilience Overlay).
- Complimenting regulatory strategies with funding and technical capacity. Resources like Norfolk’s Home Rehabilitation and Green Home Choice Programs and Norfolk’s Design Principles for Multifamily Development support developers, owners, and operators as they build more resilient and affordable housing and streamline administrative and cost barriers.
- Lowering flood insurance premiums for residents by participating in the federal National Flood Insurance Program's Community Rating System. This voluntary incentive program provides

residents a discount on their flood insurance premiums in exchange for the city implementing floodplain management practices that go above minimum NFIP requirements.

Source: Katie Spidalieri, et al, 2022, “Greasing Resilience at Home City of Norfolk, Virginia: PlaNorfolk 2030, Norfolk Vision 2100, and Resilience Zoning Updates,” Washington, DC: Georgetown Climate Center, <https://www.adaptationclearinghouse.org/resources/greasing-resilience-at-home-city-of-norfolk-virginia-planorfolk-2030-norfolk-vision-2100-and-resilience-zoning-updates.html>

PILLAR 2: NEIGHBORHOOD AND COMMUNITY INFRASTRUCTURE



Natural and physical infrastructure at the neighborhood and community scale can enhance housing resilience or exacerbate climate exposure. This infrastructure includes transportation infrastructure; utility and service infrastructure; public spaces; protective infrastructure like levees, sea walls, and bioswales; and natural assets like wetlands, lakes, and tree canopy coverage.

Why it matters: Strong built and natural infrastructure at the neighborhood and community level are key components of resilience planning. They can increase sustainability, reduce hazard exposure, lower household costs for renters and owners, and promote health and well-being.

Planning for climate readiness at the neighborhood scale can also reduce investment costs for property owners while supporting resident safety for everyone, including renters. For example, neighborhood-level heating and cooling centers can be used by all and may reduce the need for individual property owners to retrofit older heating and cooling systems. Similarly, “green” floodwater infrastructure, such as bioswales, permeable pavement, and wetland restoration, benefits entire neighborhoods and reduces cost burdens on individual property owners to manage storm runoff and floodwater.

Neighborhood-level decisions should be made with an equity lens to avoid protecting some neighborhoods at the expense of others. For example, flood mitigation decisions—such as where to site levees and bioswales or which wetlands to remediate—should consider which locations and residents will benefit. Historical disinvestments in flood protections in Black neighborhoods in Houston made them much more vulnerable and among the hardest hit after Hurricane Harvey. Other areas in Houston that had greater shares of higher income and white residents benefited from protective berms, levees, and stormwater infrastructure that mitigated the worst impacts.¹¹

Neighborhood-level infrastructure can advance both sustainability and economic well-being for residents. For example, distributed energy technologies that provide on-site electricity generation, such

as zero-emission solar microgrids on a shared local network, can reduce household energy costs and greenhouse gas emissions. These smaller scale networks can also be more responsive to supply and demand than utilities, reduce energy line loss resulting from large scale transmission, and improve energy system resilience to severe storms and extreme weather (Patel et al. 2021).¹²

Challenges: Much of the applied climate resilience and sustainability housing resources and literature focuses on built infrastructure investment solutions, but less so on green infrastructure. Yet green infrastructure, which leverages natural plant and soil systems to provide environmental benefits, is also vital to equitable and sustainable climate-resilient housing (Johnson et al. 2021). By prioritizing built solutions (such as seawalls) over natural infrastructure, communities miss opportunities for cobenefits like improved air or water quality or natural amenities like parks.

Infrastructure decisions can also have unintended social impacts that should be accounted for and mitigated. It's also important to engage with potentially affected communities about these impacts. For example, levee siting can permanently displace residents, and building-level resilience and sustainability retrofits can require residents to leave properties for extended periods. Such displacement can have cascading impacts on the quality of life, well-being, livelihood, and social and cultural ties for those affected; these impacts may outweigh any benefits of the project.

Opportunities: Planning for resilient community infrastructure is vital to ensuring climate-resilient housing is developed and protected at scale and that any neighborhood- and community-wide benefits are distributed equitably. To advance climate-resilient housing at the neighborhood and community scale, planners, policymakers, and developers can consider benefit-cost analyses for improvements to infrastructure (see box 2); ensure meaningful community engagement and planning in project decisionmaking; prioritize green infrastructure investments and integrate these investments with grey infrastructure planning; and identify distributed, neighborhood-scale energy development opportunities. For example, green infrastructure investments—such as bioswales, permeable pavement, wetlands restoration, and rain gardens—although increasing, are still underutilized for climate regulation and hazard mitigation purposes relative to grey infrastructure like dams, levees, and other traditional hardscape engineering infrastructure. Planners can identify climate and environmental hazards that can be addressed using both approaches and prioritize investment cobenefits from green improvements in areas that have lacked such investment historically.

BOX 2

Incorporating Social Cost-Benefit Assessment in Boston

Traditional cost-benefit measures used to evaluate investment impacts look at financial or numerical values. But in planning for equitable climate-resilient housing, these measures also need to reflect the social costs and benefits of project impacts and outcomes. There is an opportunity for researchers to partner with community groups to support the process of first identifying and then quantifying these social costs and benefits—to broaden the perspective traditionally taken in assessing project cost efficiency. For example, to advance environmental and housing justice for low-income and historically marginalized populations in greater Boston, researchers from the University of Massachusetts and the Lincoln Land Policy Institute worked with community members, developers, planners, and practitioners to develop a research agenda and planning framework for climate-resilient housing based on priorities identified through extensive community engagement. Key considerations included:

- determining what groups are most impacted and who needs to be part of the decisionmaking process;
- identifying fundamental housing- and community-related values, especially among the groups that are most impacted; and
- assessing and prioritizing tradeoffs when conflicting objectives arise, especially for objectives that are associated with traditional cost-benefit analyses, such as issues of standing and who benefits most and least.

Source: Michael Johnson et al., 2021, “Climate and Housing Crisis: A Research Agenda for Urban Communities,” Cambridge, MA: Lincoln Institute of Land Policy. <https://www.lincolinst.edu/publications/working-papers/climate-housing-crisis>.

PILLAR 3: HOUSING STOCK



Characteristics of the physical structure of the home include the housing type, building materials, energy efficiency profile, hazard mitigation features that influence accessibility, the cost of heating and cooling, the likelihood that the structure withstands hazards, and the amount of greenhouse gases that the building emits.

Why it matters: The housing stock in the United States, especially for affordable housing, is old, and there are persistent gaps in housing quality. Nearly one-half of the owner-occupied housing stock was built before 1980, and 8.4 percent of renter-occupied housing stock is considered moderately or severely inadequate based on structural deficiencies or absence of plumbing, electricity, or water (Joint Center for Housing Studies 2023a). Much of the country’s housing stock predates awareness of climate and environmental risks and technology for weatherization and energy efficiency. While some jurisdictions have piloted innovative code rewrites or amendments to prioritize sustainability and

resilience, there is no national standard for building new climate-resilient housing stock. And, at the federal level, most disaster-related dollars go to postdisaster housing recovery, rather than proactively mitigating risks. As a result, many residents live in units that do not protect their health, financial wellbeing, stability, and property from climate risks. A move to improve housing resilience must consider shifts in where new housing units are built and how these housing units are designed. With proper preparation and mitigation, fewer households could experience the levels of acute loss of property, setbacks to wellbeing, and displacement in future disaster events.

The success of efforts to reduce greenhouse gas emissions also hinges on making changes to how we live, as the residential sector contributes one fifth of the nation's energy consumption. Energy efficient retrofits of existing homes and green building standards for new construction will be critical drivers in meeting national emissions targets and slowing the pace of warming. These retrofits also yield multiple direct benefits to residents. Green building and energy efficiency is linked to improved health outcomes, such as reductions in asthma rates and symptoms, due to improvements in indoor air quality and less likelihood of mold exposure, as well as more acute health outcomes during extremely hot and cold days (Colton et al 2015). Energy efficiency also supports residents' financial health by reducing or eliminating utility costs, which are a major driver of residential cost burden. Economic analysis of these retrofits shows that over time, resilience and energy efficiency investments will pay for themselves, reducing or eliminating long-run household energy costs. Economic impact assessments of solar installations, for example, also find that residences with property-level solar sell for higher amounts than those without (NREL 2008).

Addressing housing resilience at the unit level is especially important for low-income populations and residents of affordable housing, as it is long demonstrated that affordable housing is often located in floodplains and other hazardous locations due to land prices (Godschalk 1999), increasing the exposure of people with low income to hazards. Mobile homes—a common form of unsubsidized housing in the US—are particularly vulnerable to climate hazards (Rumbach, Sullivan, and Makarewicz 2020). This vulnerability must be understood in the context of intensifying hazards and compounding risk under climate change.

Challenges: Owners, residents and developers face several barriers to advancing climate-resilient housing. There are significant concerns about the quality of existing affordable housing stock, both subsidized housing and “naturally occurring affordable” housing, and many units are not in compliance with current code. Owners and operators who are interested in energy efficiency or resilience upgrades must first address the health and safety improvements required to bring a building or unit to code. Historic resilience investments through the Inflation Reduction Act and the Infrastructure Investment

and Jobs Act are available for developers and property owners in the form of tax credits, subsidies, and grants, yet most of these opportunities do not cover the remediation required for initial code alignment. This means that owners and residents of older units may forego upgrade opportunities like solar to avoid triggering the need for more substantial rehabilitation.

In a postdisaster recovery context, there is a tension between quickly deploying housing for recovery and deploying sustainable and resilient approaches with more upfront costs. There is a nonlinear relationship between disasters and policy development for resilient, sustainable building codes. While disasters can generate momentum and attention to these issues, evidence also shows that there may be some regression as owners/residents prioritize returning home quickly and at the lowest cost.¹³ Degree of insurance—or underinsurance—also informs the ability of homeowners and small landlords to rebuild after disaster. In many communities, there has been insufficient investment in planning and mitigation to be prepared to make better rebuilding decisions in the aftermath of disasters. This is especially true for smaller or less capitalized communities. Finally, technology, skilled labor and materials needed for mitigation and green retrofits is in high demand and short supply—training and workforce development are needed.

Opportunities: Communities are exposed to different hazard profiles related to climate and the environment. Local actors can support action in this pillar by creating tailored resources and retrofit strategies that align with their community’s building typology, local climate hazard profile, and housing affordability needs (see box 3). By bringing together outcomes for sustainability, hazard mitigation, and environmental justice, local governments can look to incentivize property owners/developers and allow greater flexibility of funding sources. This could encourage a holistic approach to resilience retrofits for sustainability and hazard mitigation while also building equity into guidelines for buy-out programs and other programs to preserve or expand the supply of affordable housing in a community.

Replacing roofing, windows, doors, and siding, and upgrading insulation, HVAC equipment, and electrical components can all improve the energy efficiency of housing units. While these property maintenance actions are typically the domain of the owner, local jurisdictions can help owners and residents connect to available funding and technical assistance through programs like the Weatherization Assistance Program and Energy Star. Jurisdictions can also create supplementary programs to help fill the gaps, especially for low-income homeowners or renters who may face barriers. These actions contribute to both improving the physical and financial health of residents and reducing greenhouse gas emissions.

BOX 3

Addressing Wildfire Risk in California: CalFire's Wildfire Action Plan

Building for resilience requires a careful focus on the land use, building characteristics, and hazard profiles in place. Historically, much of the attention for hazard mitigation has focused on preventing risks from flooding; however, an increasing share of damages is driven by wildfires. To help owners and residents prepare for this risk, CAL Fire released a wildfire action plan that includes both mitigation and preparedness actions.

To mitigate risk of wildfires, the guide calls for a two-pronged approach to create and preserve defensible space through buffers between buildings and vegetation and retrofitting properties with fire-resistant materials. This may include replacing wood roofs and retrofitting windows, decks, exterior walls, rain gutters, fences, and other household features.

But changes to the building unit are only one half of the equation. CAL Fire also encourages residents to preparedness action such as creating a wildfire action plan, maintaining an emergency supply kit, and developing a home inventory aligned with insurance coverage.

Source: CalFire, "Prepare for Wildfire," accessed December 21, 2023, <https://www.readyforwildfire.org/prepare-for-wildfire/get-set/wildfire-action-plan/>.

PILLAR 4: PEOPLE AND SOCIAL CAPITAL



Individual and household-level social capital assets and community-level social capital shape how households and communities respond and adapt to the impacts of climate change. Individual-level assets include awareness of risk, access and uptake of insurance products, and emergency planning. Community-level assets include community cohesion, prevalence and coordination of community groups, and the strength and accessibility of local government.

Why it matters: Social capital infrastructure—including relationships and coordination across and between government agencies, private providers, businesses, and community and civic groups—is vital to responding quickly and effectively to disaster events (Junod et al. 2023). Higher levels of social capital are associated with greater access to and uptake of resources and supports for planning and mitigation to prepare for disasters (Aldrich 2012) and greater community resilience in the aftermath of disasters (Völker 2022). For example, social capital can help residents organize and advocate for improving HVAC systems in rental units, access higher-rated air filters as poor air quality days increase, or establish heating and cooling centers in their communities.

While social capital infrastructure assets are vital for disaster-prone communities to address acute response and recovery needs, they are also essential for longer-term and proactive sustainability and resilience efforts. To successfully meet community needs, these longer-term efforts require social engagement and social capital to inform project design, build buy-in, and guide implementation. This can entail local government, developers, and/or community planners to build processes and relationships to engage with community members most impacted by climate challenges or providing support to bolster advocacy for and access to housing resources.

Challenges: Advocacy is a core component of social capital infrastructure, yet some groups are less able to advocate for their needs, limiting their capacity to adapt to climate change. For example, renters are traditionally less coordinated and resourced than their homeowner counterparts, despite being at greater risk of negative outcomes and longer recovery periods if displaced. Renters also have less agency to make mitigation or sustainability improvements to their residences. Other socially vulnerable populations are less able to advocate for their needs, including people with low incomes, people who speak languages other than English, older populations, very young populations, immigrant and refugee populations, people with disabilities, and many populations of color, especially those who live in neighborhoods that continue to experience disproportionate environmental and climate risk due to the ongoing legacy of racist housing, planning, and lending practices. Planners, developers, and policymakers often fail to reach these groups.

Improving the social resilience of these populations—whether through increased community engagement, cross-group coordination, or individual education—typically receives less attention than physically shoring up housing supply and community infrastructure. Yet social resilience is critically important for advancing housing resilience, particularly with an eye toward equity and environmental justice. This is especially true for frontline communities experiencing multiple, compounding hazards over time.

Opportunities: Local housing actors should be intentional about how to build social capital and community connections to promote resilience. This might look like building community power for decisionmaking on climate resilience (see box 4), including through community advisory boards composed of those most impacted by climate impacts. Or it might look like integrating climate-related education, resources, and priorities into existing tenant organizing efforts and tenant right's policies. Developing, updating and socializing emergency management plans at the household and community level can proactively help people connect to each other and to emergency response resources.

Being thoughtful about the individual experience of climate hazards also requires considering the mental stress and anxiety that can result from hurricanes and other extreme weather events and deploying culturally, appropriate mental health services. Supporting people with low and moderate incomes by providing financial resources and instruments to help them weather the storm is also important for building capacity at the household level. One approach is to encourage and incentivize disaster savings accounts to help residents plan financially for disasters.

BOX 4

Investing in Resilience and Sustainability with Distributed Energy in Puerto Rico

Nonprofit and community-owned models of neighborhood-scale distributed energy generation can provide reliable, affordable energy that reduces emissions and strengthens community social infrastructure and energy resilience.

Barrio Eléctrico is a nonprofit distributed energy organization that works to improve the lives of Puerto Ricans by increasing community resilience to future disasters and electrical outages. Barrio Eléctrico's "community model" for access to solar energy, distributed energy planning and investments works to increase access and affordability to distributed energy by doing the following:

- establish partnerships with private sector, public sector, and community organizations to resource and install energy technologies at affordable rates
- provide community education on energy efficiency and energy transitions away from hydrocarbon fuels
- strengthen community social capital and cohesion by creating jobs and promoting knowledge and resource sharing

Source: Barrio Electrico, "Solar Technology and Service," accessed December 21, 2023, "<https://www.barrioelectrico.org/>

Benefits of Addressing Housing Resilience Holistically

Our climate-resilient housing framework integrates sustainability, resilience, and environmental justice principles to equip local and regional housing developers, planners, policymakers, and advocates with information, resources, and framing to advance climate-resilient housing in their communities. By using this integrated, pillared approach, housing stakeholders can achieve multiple crosscutting sustainable housing outcomes, including (1) connecting oftentimes siloed housing actors and sectors; (2) creating numerous economic, social, and environmental benefits; and (3) developing a long-term and proactive

strategy for a sustainable and equitable housing stock that is resilient to the impacts of a warming climate.

Connect Siloed Sectors and Actors

Developing new climate-resilient housing or improving the resilience of existing housing requires new collaborations across housing sectors and actors to plan, design, manage, build, and retrofit housing stocks in new ways. Navigating these changes will require those involved to be proactive, adaptable, and willing to break from the status quo. To support needed coordination, local governments can work with area housing actors and community stakeholders to convene resilient housing coalitions. The resources and guidance in this document can help stakeholders coordinate and act across all pillars of the framework.

Resilient housing coalitions can use the framework to identify stakeholder groups across the four pillars and to investigate their priorities and motivations for change. They can also take stock of current inequities in the housing system, prioritize beneficiaries, and plan activities by identifying the unique ways the changing climate affects different coalition actors, community members, and geographies.

Coalition size and composition will vary with community characteristics and housing resilience goals, but key actors and respective roles that coalitions can consider are listed in table 1.

TABLE 1
Actors Who Can Advance Climate-Resilient Housing

Actor	Examples	Roles
federal government	Department of Housing and Urban Development, Department of Energy, Federal Emergency Management Agency, Environmental Protection Agency	<ul style="list-style-type: none"> ■ develop federal policy and implement programs ■ set regulatory standards ■ allocate federal funding ■ invest in capacity-building activities to advance climate-resilient housing goals
state and local governments	city and county housing and planning departments, regional planning and transit authorities, state housing finance and disaster recovery agencies	<ul style="list-style-type: none"> ■ develop state and local policy and implement programs to set regulatory standards, allocate funding, provide resources and capacity-building to advance climate-resilient housing goals
utility sector	electricity, water, sewer, gas, garbage, and recycling providers	<ul style="list-style-type: none"> ■ manage the provision of utilities in ways that encourage decarbonization and sustainability and fortifies energy systems and other public infrastructure against climate hazards

Actor	Examples	Roles
insurance providers	private sector insurance providers; state, local, and federal public insurers; disaster insurers, such as the National Flood Insurance Program	<ul style="list-style-type: none"> provide insurance that adequately manages risk, maintains affordability, and encourages climate-resilient housing
lenders	traditional banks, community development financial institutions, green banks, government sponsored enterprises	<ul style="list-style-type: none"> provide capital to finance mortgages, capital stacks, renovation and retrofit loans, and other financial products that help finance climate-resilient housing
housing developers, owners, and operators	public housing authorities, community development corporations, for-profit and nonprofit housing developers, corporate landlords, mom-and-pop landlords, building managers	<ul style="list-style-type: none"> manage and execute the development, rehabilitation, preservation, maintenance, and operations of climate-resilient housing
trade sector	contractors, architects, engineers, appraisers, real estate agents and firms	<ul style="list-style-type: none"> oversee and provide technical expertise and capacity to design, build, maintain, inspect, assess, and sell climate-resilient housing
intermediary organizations	private and corporate philanthropy, research institutions, advocacy organizations	<ul style="list-style-type: none"> provide risk capital to seed innovation and fill resource gaps analyze and document needs and opportunities evaluate programmatic and intervention impacts and outcomes advocate for changes to improve climate-resilient housing
residents	renters, homeowners, tenant associations, homeowner associations	<ul style="list-style-type: none"> improve household and community climate resilience through individual actions and preparedness advocate for climate-resilience needs to actors with other levers of power

Source: Authors' analysis.

Create Economic, Social, and Environmental Benefits

Addressing housing resilience across the four pillars of our climate-resilient housing framework can result in numerous community benefits. By targeting benefits to a broad coalition of stakeholders, coalition groups can increase the range of investment types beyond what may be available through traditional housing finance options alone. For example, by focusing on both sustainability and resilience considerations, a housing project can attract traditional housing dollars, green financing dollars, and federal and state disaster-mitigation funds. Resilience housing coalitions can also attract new funders by emphasizing the benefits that are most appealing to a specific group. For example, highlighting the health benefits of sustainability and resilience retrofits can attract funding from health and hospital systems or from philanthropic investors interested in supporting community health and wellness.

Below, we summarize the primary benefits of climate-resilient housing, which include mitigating disaster impacts on housing, reducing greenhouse gas emissions, promoting housing stability and affordability, building and protecting financial health and wealth, and improving community health and well-being.



Mitigating disaster impacts on housing. Housing resilience investments that harden residential and community infrastructure against climate impacts will both reduce risks to future climate disasters and lower household- and community-level damage and recovery costs when disasters occur. Such investments will also help stabilize many populations that are at risk of becoming displaced by disasters due to low quality or unsafe housing, allowing more people to remain in their homes. Making properties better able to withstand severe weather and disaster events reduces the risk of human loss and social costs from displacement.



Reducing greenhouse gas emissions. Many investments that improve housing resilience to climate change also reduce contributions to greenhouse gas emissions, thereby reducing housing sector contributions to climate change. For example, distributed, renewable technologies such as energy microgrids are more stable and reliable against climate change-induced severe weather, disasters, and extreme temperatures than centralized utility-scale generation because any disruptions or outages are not widespread (Jeffers et al. 2018). Further, when energy for distributed technologies is generated from renewable sources, such as wind or solar, energy system emissions are reduced significantly, curbing climate impacts.



Promoting housing stability and affordability. Investing in new climate-resilient housing and retrofitting existing housing to be more climate resilient can improve housing affordability and access for everyone, especially populations with low incomes who experience housing and energy insecurity. When housing developers and owners invest in more efficient, sustainable, and protective building materials, appliances, and HVAC systems, they can help fortify and preserve existing stock to help meet current and future housing demands and reduce resident home energy cost burdens. Protective investments also help keep people in their homes in the event of disasters, reducing downstream household and community costs from displacement.



Building and protecting financial health and wealth. Housing resilience investments that electrify residential and community energy systems and weatherize residences can reduce monthly utility bills and many such distributed and local-scale investments pay for themselves within a few years. Many of these investments also increase home values directly or protect against losses in home value in the event of disasters, helping protect and build equity for property owners over time. This is especially impactful for homeowners with lower incomes and homeowners of color, who tend to have higher shares of their wealth tied to homeownership.



Improving community health and well-being. Housing resilience investments that electrify residential and community energy and HVAC systems improve indoor air quality through air purification and reduction in exposure to carbon monoxide and nitrogen dioxide, which are emitted from gas-fueled appliances and heating systems. At the community level, air quality is also improved with utility-scale decarbonization and electrification. Taken together, shifts toward renewable energy and electric heating and cooling technologies can help improve health outcomes for residents by reducing their exposure to pollution and harmful emissions. Further, mitigation and protective investments that prevent or lessen damage from climate-induced disasters also benefit residents, helping protect against physical and mental health consequences that result from wildfires, flooding, severe storms, and extreme temperatures. Finally, improvements that weatherize residences—in addition to making them more resilient to climate hazards—have additional benefits of improving home heating and cooling efficiency, thereby promoting residential comfort.

Shifting from Disaster Response to Planning Ahead

The orientation of most federal disaster relief funding—and as a consequence, most resources for mitigation and planning—is crisis. Most investments that address climate change–related housing needs come in response to major disasters. Although there has been progress toward expanding energy efficiency programs and other renewable technologies and standards that are necessary for the housing sector to become climate-resilient, the majority of federal investments are designed to address past disaster events.

In contrast, our climate-resilient housing framework provides an architecture to identify and prioritize the policies, programs, and funding streams that advance or impede housing sustainability, resilience, and environmental justice in times of relative stability and in response to disasters across all four pillars of community housing needs. Because of this, it can support housing coalitions to act proactively and with a continuous planning horizon that assumes both chronic and acute climate impacts will affect their housing stocks. Our climate-resilient housing framework supports preparation and planning that is coordinated, equity-based, and future-oriented.

The shift from postdisaster response and recovery to a continuous and forward-looking approach will require policymakers, planners, housers, and stakeholders to integrate the four pillars of housing resilience into all aspects of planning, development, financing, and policymaking. It also requires these stakeholders to prepare so that they are able to act on the unique opportunities that arise during both stable times and crisis response. During periods of relative stability, local leaders can use the framework to identify ongoing and emergent housing needs, evaluate the effectiveness of current interventions, and plan ahead. During periods of acute climate crisis or disaster response and recovery, they can act on previous planning and weigh opportunities for transformational change that can embed climate readiness and equity into the housing ecosystem. This type of “fast and slow” planning and resource deployment is also needed for related shifts in housing demand driven by climate migration (Junod et al. 2023), and will help communities be responsive and resilient to changing conditions as they happen.

Looking Ahead: From Framework to Action

In our interviews with housing policymakers and planners, we identified key planning and policy-relevant evidence, resources, and tools that can support coordinated action to advance equitable

climate-resilient housing for communities. When working to create climate-resilient housing stocks, housing coalitions can assess the quality and availability of the following resources for their communities and consider where there may be opportunities to address identified gaps and who might be able to address them.

- **Data and evidence:** Housing coalitions require data and evidence about future potential climate hazards at low levels of geography so they can assess risks at localized levels and make tailored plans and decisions accordingly. They also need resources to understand different population and household needs before climate disasters occur, as well as during impact and longer-term recovery periods.
- **Evaluation tools:** Planners and policymakers need systems and tools to evaluate the efficacy, impact, and equity of different housing-resilience plans and interventions. These could include decision models to aid in prioritizing different climate and disaster investments, key metrics and measures to assess impacts and equity at different stages of climate crises or disasters, and comprehensive process and outcome evaluations of how existing programs are working and their impacts and benefits for different populations.
- **Insurance and finance tools:** Housing actors need research and resources about new models of insurance that more equitably spread risk, increase access, limit losses, and incentivize resilience. Relatedly, there are unmet financing needs and related planning needs, including additional resources to reduce risk for private sector sustainability and resilience investments, and new supports to unlock private capital to leverage federal programs addressing climate and disaster impacts and housing.
- **Collaboration:** Housing developers, community planners, policymakers, and advocates who are siloed across institutions and sectors emphasized the need for greater coordination between and across institutions to advance sustainability, resilience, and environmental justice priorities and goals. For example, both policymakers and developers shared a desire to better collaborate with utility companies to better understand household energy usage and needs, as well as with financial institutions to develop better financing tools to advance climate-resilient housing.

The opportunity to achieve ambitious decarbonization goals and limit the catastrophic and irreversible impacts from climate change is closing quickly. This decade provides a critical window to make meaningful progress and build a foundation for a climate-resilient future. With the recent passage of major federal legislation like the Inflation Reduction Act and the Infrastructure Investment and Jobs Act—coupled with increasing policy action in many state legislatures—resilient housing coalitions and

stakeholders have an unprecedented opportunity to leverage these policies and capitalize on political and economic momentum.

These new federal and state investments—and the new ways of coordination and planning they will require—may add complexity and strain in the short term. But moving quickly to build and strengthen partnerships and adopt and implement new practices will be critical for making use of these funds and ensuring the affordable housing sector provides equitable access to the benefits of climate resilience for individuals, households, and communities across the country.

Appendix A. Definitions of Key Terms

The language decisionmakers use to define challenges and solutions dramatically shapes the outcomes they can achieve within their communities. To help clarify how our framework can inform local action, we define the concepts that are foundational to our definitions of climate resilience, equity, and housing affordability.

- **Sustainability:** Society’s ability to meet the resource and service needs of current and future generations without compromising the health of the ecosystems that provide those resources and services (Brundtland, 1987). In the context of climate-change mitigation, sustainability describes reducing the flow of greenhouse gasses into the atmosphere, either by reducing the sources or use of gasses, by enhancing the “sinks” that accumulate and store gasses, or both.
- **Resilience:** The capacity of a system to return to a stable state following an acute shock. In the context of climate-change adaptation, resilience describes the ability of a community or system to anticipate, adapt to, and recover from climate impacts in a timely and efficient manner.
- **Environmental justice:** The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.¹⁴ Fair treatment means no groups of people bear a disproportionate share of the environmental consequences of industrial, governmental, and commercial operations and policies.
- **Hazard:** a potentially destructive environmental, climate, or weather-related phenomenon (e.g., wildfire, extreme heat event, flooding).
- **Exposure:** the people, places, resources, environments, and infrastructure that could be negatively affected by a hazard.
- **Vulnerability:** a characteristic that increases the likelihood of harm, damage, or destruction from a hazard. For example, a five-story multifamily housing complex may be more vulnerable to shaking from an earthquake and more likely to collapse than a single-family home. A low-income homeowner may be vulnerable to a flood because they lack the financial means to prepare for or respond to damages.

- **Distributive equity:** the fair distribution of benefits and burdens across all people in a community from investments, including prioritizing benefits to those with the highest need, vulnerability, or risk. Planning for climate-resilient housing that advances distributive equity considers how historical patterns of land use and segregation intersect with current and future climate risks and identifies which populations are most vulnerable to physical and social climate shocks and stressors. Distributive equity is *outcomes* oriented and addresses “who gets what” in relation to how benefits, harms, and resources are distributed.
- **Recognitional equity:** the fair distribution of benefits and burdens across people in a community in a manner that addresses past disparities and the different histories, backgrounds, and situations of affected populations by prioritizing populations who have been historically underserved or disinvested. Rather than emphasizing “balance” or “equality,” recognitional equity prioritizes fairness to “level the playing field.” Climate-resilient planning that advances recognitional equity will prioritize benefits and investments for groups that are most at risk or that have been historically underserved or discriminated against, such as renters, older people, people with low incomes, people living in manufactured housing, people with disabilities, and racial and ethnic minority populations. Recognitional equity is both *process* oriented and *outcomes* oriented and is a precursor to distributive and procedural equity.
- **Procedural equity:** inclusive, accessible, and authentic engagement, representation, agency, and authority in planning and decision making. Achieving procedural equity includes operating with transparency, neutrality, and legitimacy. It includes ensuring that the people who are most affected by investment decisions have a meaningful voice and “say” throughout all parts of planning and development processes. It also requires securing and continually maintaining trust, support, and “social license” from people who will be most affected by planned investments, or who have already experienced disproportionate harms from past decisions. Climate-resilient housing planning that advances procedural equity will meaningfully engage the populations most affected by climate impacts and housing resilience investments as partners in issues prioritization, solution planning, and development over the course the project lifecycle. Procedural equity is primarily *process* oriented.
- **Affordable housing:** housing that costs no more than 30 percent of a household’s income. For owners, housing costs include principal, interest, property taxes, hazard insurance, and owner-paid utilities. For renters, costs include rent and tenant-paid utilities (excluding internet, cable, and telephone services).

- **Affordable housing for low-income households:** affordable housing for households earning at or below 80 percent of the area median income.
- **Subsidized affordable housing:** affordable housing that relies on federal, state, or local government programs to reduce the cost of housing for low- and moderate-income residents. There are two general types of housing subsidies: (1) development subsidies (supply side) to help construct or acquire housing, and (2) operating subsidies (demand side) that supplement the amount that residents can pay.
- **Unsubsidized or “naturally occurring” affordable housing:** affordable housing that is not subsidized by any federal, state, or local program. “Naturally occurring” affordable housing is most often rental housing with relatively low rents compared to the regional housing market. Typically, its older housing stock and is more prone to housing quality issues.

Appendix B. Guiding Questions to Assess Community Climate-Resilient Housing Needs

Assessment is a critical first step in understanding the state of a community’s housing stock and identifying what it will take to improve climate resilience. Climate-resilient housing looks different in every community. The effective levers of change, influential actors, and equity considerations vary by place. To adequately assess your community’s needs, it is important to consider the current and future climate risks facing the housing stock and the extent to which the four pillars of housing resilience advance or inhibit climate resilience in your community. Table B1 outlines questions that can guide your assessment.

TABLE B1
Guiding Questions to Assess Climate-Resilient Housing Needs

Assessment domain	Guiding questions
Climate risks	<ul style="list-style-type: none"> ▪ What are the chronic and acute climate risks facing your community? How will risks change over time? ▪ How do climate risks in your region pose different levels of threats to different segments of your community? To what extent do these threats compound existing layers of disadvantage? ▪ How do the climate risks and differential impacts of those risks in your community compare to the risks facing neighboring communities, the region, and the state?
Policy and finance	<ul style="list-style-type: none"> ▪ In what ways does your local policy environment encourage and/or discourage climate-resilient housing? How do land-use plans, zoning ordinances, and building codes affect chronic and acute climate risks and sustainability goals? ▪ To what extent is climate resilience a priority to policymakers in your community, your region, and your state? How do actors across jurisdictions coordinate to identify and advance sustainability and resilience priorities? ▪ What local, regional, state, and federal programs do you have access to in your community to advance climate resilience? What is your community’s capacity to attract, absorb, and deploy capital from these programs and the private market?
Neighborhood and community infrastructure	<ul style="list-style-type: none"> ▪ What built and natural community assets protect against climate risks and improve sustainability in your community? Who are the primary beneficiaries of infrastructure investments? ▪ What green and grey infrastructure investments could improve the resilience and sustainability of your community? ▪ Are there any patterns of prioritizing or excluding certain neighborhoods or people in your community? How can future investment decisions redress past imbalances and advance equity? ▪ To what extent are neighborhood and community organizations empowered to invest and develop in neighborhood-scale infrastructure like distributed

Assessment domain	Guiding questions
Housing stock	<p data-bbox="610 281 1422 365">energy and green stormwater management systems? What relationships, capacities, and/or policies need to be established or strengthened to empower neighborhood-level actors?</p> <ul style="list-style-type: none"> <li data-bbox="565 369 1317 426">■ What is the state of housing affordability in your community? Which households are most in need of affordable housing? <li data-bbox="565 430 1398 487">■ What are the housing characteristics of your community in terms of housing type, quality, tenure, and subsidized and unsubsidized housing? <li data-bbox="565 491 1406 548">■ How do the risks of acute and chronic climate shocks affect different housing stocks? <li data-bbox="565 552 1406 625">■ To what extent does your community’s housing workforce have the capacity and expertise to finance, design, build, and retrofit climate-resilient housing? Where are there gaps and how could they be strengthened?
People and social capital	<ul style="list-style-type: none"> <li data-bbox="565 632 1422 743">■ How do households assess their capacities to respond to chronic and acute climate challenges that affect their housing? What resources and supports are needed to increase household capacity, particularly for those with the least resources? <li data-bbox="565 747 1406 831">■ What formal and informal relationships exist across and between community institutions that are involved in climate-resilient housing planning? What relationships with which community groups can be strengthened? <li data-bbox="565 835 1422 884">■ How can emerging workforce needs be used to create high-quality jobs for the most disadvantaged members of your community?

Source: Authors’ analysis.

Appendix C. Data Resources for Understanding Community Needs

There are several data tools that can help assess a community's housing stock and opportunities to improve climate resilience. These publicly available datasets can help assess climate-resilient housing dimensions across environmental justice, resilience, and sustainability:

- **Screening for Environmental Justice: A Framework for Comparing National, State, and Local Data Tools.** Compiles a wide range of national, state, and local environmental-justice data tools and includes indicators related to housing.
<https://www.urban.org/research/publication/screening-environmental-justice-framework-comparing-national-state-and-local>
- **Resilient MA Maps and Data Center.** Outlines climate data and projections to support climate resilience efforts across Massachusetts. <https://resilientma-mapcenter-mass-eoea.hub.arcgis.com/>
- **FEMA Risk Rating 2.0: Equity in Action.** Provides flood risk rating profiles for every state in the US. <https://www.fema.gov/flood-insurance/risk-rating>
- **FEMA National Risk Index for Natural Hazards.** An interactive mapping tool that illustrates risk for communities in the US related to 18 types of natural disasters.
<https://hazards.fema.gov/nri/>
- **FEMA Resilience Analysis and Planning Tool (RAPT).** Provides data on community resilience indicators, demographics, infrastructure, weather, hazards, and risk across the US.
<https://www.fema.gov/emergency-managers/practitioners/resilience-analysis-and-planning-tool>
- **Climate Mapping for Resilience and Adaptation.** An interactive mapping tool that offers real-time information on climate-related hazards across the US. <https://resilience.climate.gov/>
- **First Street Foundation Risk Factor Tool.** Provides property-level estimates of climate risks including flooding, wildfire, heat, and wind across the US. <https://firststreet.org/risk-factor/>
- **CDC/ATSDR Social Vulnerability Index.** Evaluates the potential effects of external stresses, including natural and human-caused disasters, on human health and helps identify communities in need of support. <https://www.atsdr.cdc.gov/placeandhealth/svi/index.html>

- **American Housing Survey (AHS)**, Provides information on the size, composition, and quality of housing across the US. <https://www.census.gov/programs-surveys/ahs.html>
- **Census Bureau Housing Data**. Compiles data on housing affordability, housing patterns, housing vacancies, housing construction, rental housing, and residential financing. <https://www.census.gov/topics/housing.html>
- **HUD: Comprehensive Housing Affordability Strategy Data**. Demonstrates the extent of housing problems and housing needs, particularly for low income households. <https://www.huduser.gov/portal/datasets/cp.html>

Appendix D. Resources and Toolkits for Advancing Climate-Resilient Housing

Organizations across the country have created resources to support different dimensions of climate-resilient housing. These resources are most relevant to climate-resilient housing efforts:

- **City of Boston Retrofit Resources Hub:** The Resource Hub outlines emission reduction options, technical resources, and financial resources for multifamily and commercial building owners or managers, contractors, residential tenants, and commercial tenants.
<https://www.boston.gov/departments/environment/retrofit-resource-hub>
- **Resilient Retrofits Climate Upgrades for Existing Buildings:** This report outlines the opportunities and challenges of preparing existing buildings for accelerating physical climate risks for real estate actors, designers, policymakers, and finance professionals. It introduces design strategies for various climate risks, public-sector policies, and financing solutions for retrofits.
<https://knowledge.uli.org/en/Reports/Research%20Reports/2022/Resilient%20Retrofits>
- **Ready to Respond: Strategies for Multifamily Building Resilience:** This manual provides recommendations to help multifamily housing developers, owners, and organizations adapt and respond to climate change, climate hazards, extreme weather events, and other threats.
<https://businesscontinuity.enterprisecommunity.org/sites/default/files/strategies-for-multifamily-building-resilience.pdf>
- **Identifying, Valuing, and Financing Climate Resilience in Multifamily Affordable Housing:** This report discusses challenges to enhance the climate resilience of multifamily affordable housing, existing funding resources, and the incentives that would motivate the building of climate-resilient housing. <https://sahln.energyefficiencyforall.org/sahln/sahln-resources/identifying-valuing-and-financing-climate-resilience-multifamily-affordable>
- **DC DOEE Resilience and Solar Assessment Tool User Manual:** This manual provides a guide for multifamily affordable housing owners and operators in DC to identify potential resilience preparedness strategies, energy and water efficiency strategies, and solar energy and solar storage opportunities to best protect vulnerable populations, reduce operating costs, and

enhance building durability.

https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/DC%20OEE%20Resilience%20Tool%20Manual-8.28.19.pdf

- **Equitable Adaptation Legal & Policy Toolkit: Resilient Affordable Housing, Anti-Displacement & Gentrification:** This toolkit discusses approaches to enhancing the resilience of affordable housing, including approaches to preserve and create affordable housing, to increase sustainability and resilience of new and existing housing, and to minimize displacement. <https://www.georgetownclimate.org/adaptation/toolkits/equitable-adaptation-toolkit/resilient-affordable-housing-anti-displacement-gentrification.html>
- **Energy Equity for Renters Toolkit:** This toolkit offers guidance to local government staff, community-based organizations, affordable housing providers, lenders, utilities, and advocates on how to integrate energy efficiency and affordable housing policy, reduce greenhouse gas emissions, and preserve or create affordable housing. <https://www.aceee.org/toolkit/2022/11/energy-equity-renters-toolkit>
- **Resilience Policy Toolkit Promoting Equitable Climate Adaptation Strategies for Miami's Affordable Housing Community:** This toolkit outlines creative strategies and policies to equitably address the resilient future of Miami's affordable housing stock, summarizes climate-related policies and programs that were successfully implemented in other cities, and provides a cost-benefit analysis tool for housing resiliency. <https://affordablehousing.miami.edu/toolkits/resilience-policy-toolkit/index.html>
- **Affordable Multi-Family Housing: Risks and Opportunities:** This report analyzes challenges and opportunities for preserving, rehabilitating, and constructing affordable multifamily housing in Houston and Harris County, especially related to flood risks and flood resilient housing. <https://www.houstonconsortium.com/graphics/images/MFReport.3.19-19-FINAL-Spreads.pdf>
- **US Climate Resilience Toolkit:** This toolkit lists guides, tools, and data resources on various climate-related risks and opportunities across the US. <https://toolkit.climate.gov/tools>
- **Resilient MA: Climate Clearinghouse for the Commonwealth:** Resilient MA is an online clearinghouse that offers comprehensive information about the state's work on climate adaptation and mitigation. The clearinghouse contains science and data on expected climate changes, information on community resiliency, decision support tools, and links to grant

programs and technical assistance that local government and communities can use to fund and support actions to adapt to climate change. https://resilientma.mass.gov/rmat_home/

Notes

- ¹ Federal Reserve Bank of Atlanta, “Home Ownership Affordability Monitor,” accessed January 2, 2023, <https://www.atlantafed.org/center-for-housing-and-policy/data-and-tools/home-ownership-affordability-monitor>.
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